Placer County Flood Control and Water Conservation District
and
Sacramento County Water Agency

Final Report

Dry Creek Watershed Flood Control Plan

April 1992

JMM James M. Montgomery

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DRY CREEK WATERSHED FLOOD CONTROL PLAN

EXECUTIVE SUMMARY

GOALS AND SCOPE

The Dry Creek Watershed Flood Control Plan was sponsored by the Placer County Flood Control and Water Conservation District and the Sacramento County Water Agency. This plan covers the approximately 101 square miles of the Dry Creek watershed as shown in Figure ES-1.

Incidences of flooding along Dry Creek and its tributaries (Antelope Creek, Clover Valley Creek, Secret Ravine, Miners Ravine, Strap Ravine, Linda Creek, and Cirby Creek) are well documented. Flooding occurs when heavy rains cause streams to overflow their banks, flooding property and structures located adjacent to the streams. Streams also back up at culverts and bridges, blocking roads or making them unsafe. Emergency services can also be restricted by the flooded roads. Officials and elected representatives in both Placer and Sacramento Counties are concerned, not only with existing problems, but also with future problems which can result from the development occurring in the area. Continued development in both the upper and lower reaches of the watershed will only make the flooding problems worse unless adequate steps are taken to plan and implement comprehensive watershed-wide solutions to the drainage problems.

Satisfactory solutions to the flooding problems in the Dry Creek watershed cannot be provided on a site by site basis because of the possible adverse downstream impacts of any proposed solution. Cumulative downstream impacts must be taken into consideration when planning flood control projects and setting flood control policies. The purpose of the Dry Creek Watershed Flood Control Plan is to provide the Placer County Flood Control and Water Conservation District and other governmental agencies in both Placer and Sacramento Counties with the information and recommendations for policies necessary to manage the storm waters within the Dry Creek watershed. It also includes consideration of required improvements and the associated funding programs to accomplish the improvements. This Flood Control Plan is intended to provide an approach for meeting existing and future flood control needs in Dry Creek watershed. This study is feasibility and planning level only. Construction of the improvements described will require additional detailed planning, design, and Environmental Impact Review.

MAJOR ASSUMPTIONS

The following paragraphs contain a list of the major assumptions used in developing the Dry Creek Watershed Flood Control Plan.

- *The land use estimates for existing watershed conditions are based on 1989 aerial photography.* At the time that the watershed models were developed, only 1989 photography was available. Except for a few local areas, the estimated flows based on 1991 aerial photography would not be significantly different from those actually used.

- *The land use estimates for projected future watershed conditions are based on full buildout according to current general and specific plans.* A consistent set of land use designations were developed and applied to all areas of the watershed based on general plan information from the various jurisdictions. If the general plans are

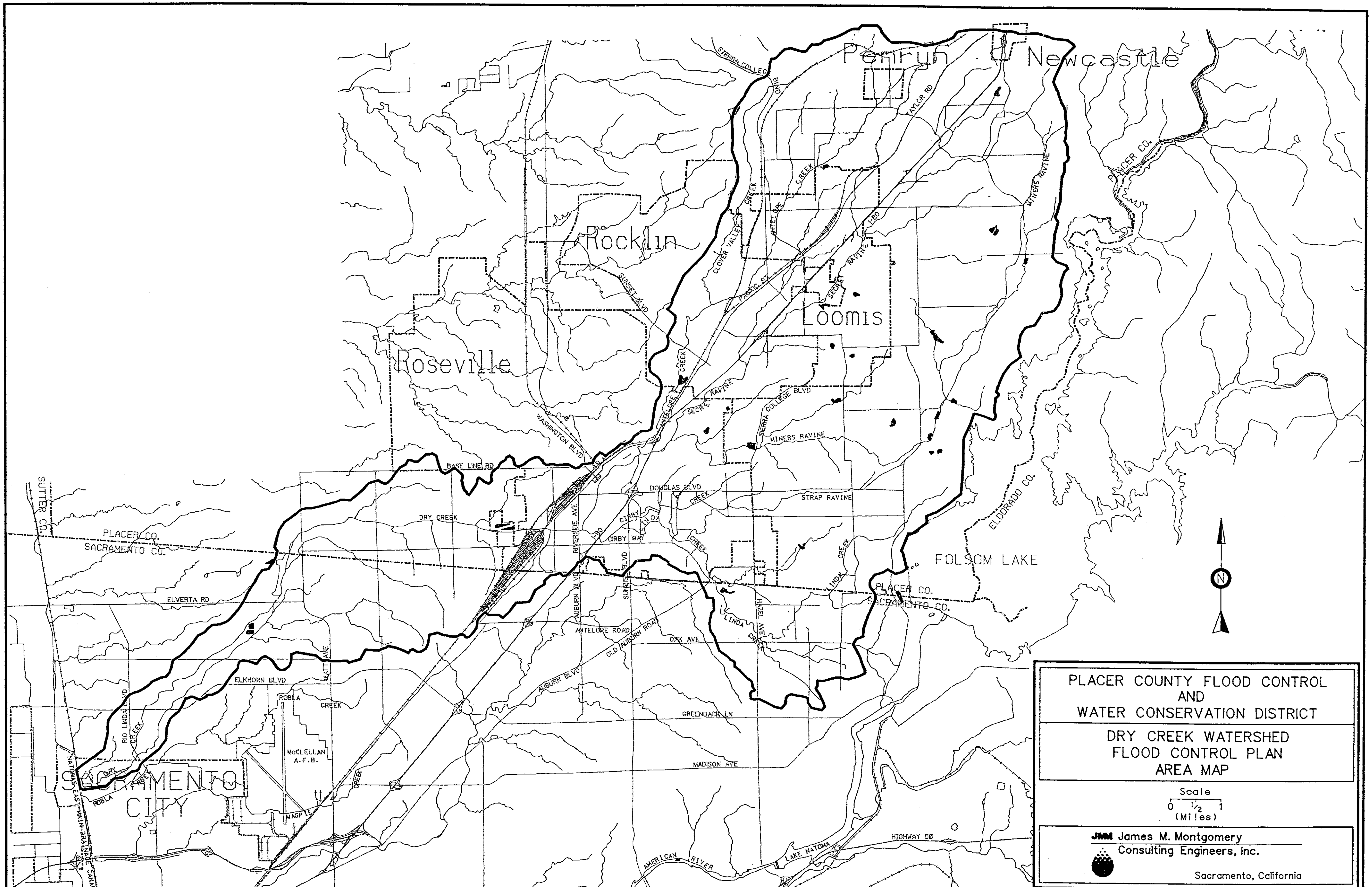

PLACER COUNTY FLOOD CONTROL
AND
WATER CONSERVATION DISTRICT
DRY CREEK WATERSHED
FLOOD CONTROL PLAN
AREA MAP
Scale
0 1/2 1
(Miles)
JMM James M. Montgomery
Consulting Engineers, Inc.
Sacramento, California
Penryn
Newcastle
Rocklin
Loomis
Roseville
SACRAMENTO
CITY
FOLSOM LAKE
PLACER CO.
SACRAMENTO CO.
SUTTER CO.
ELDORADO CO.
McCLELLAN
A.F.B.
BASE LINE RD
DRY CREEK
ELVERTA RD
ELKHORN BLVD
ANTELOPE ROAD
OLD AUBURN ROAD
OAK AVE
AUBURN BLVD
GREENBACK LN
MADISON AVE
HIGHWAY 50
AMERICAN RIVER
LAKE NATOMA
DOUGLAS BLVD
STRAP RAVINE
MINERS RAVINE
SIERRA COLLEGE BLVD
SECRET RAVINE
WASHINGTON BLVD
SUNSET BLVD
CLOVER VALLEY CREEK
ANTELOPE CREEK
LINDA CREEK
HAZEL AVE
TAYLOR RD
ROBLA
ROBLA CREEK
RIO LINDA CREEK
NATOMAS EAST MAIN DRAINAGE CANAL
N

FIGURE ES-1

amended drastically, it may be necessary to make adjustments in the flood control plan to match those changes.

- *In areas where land use densities are greater than one unit per five acres, hydrologically significant clearing of vegetation will occur along drainage ways.* It was assumed that general plan policies prohibiting clearing in the floodplain can not be entirely enforced and that vegetation will be removed along about 40% of the channels.

- *The following flood control alternatives were considered as part of the flood control plan:*

  - Regional stormwater detention basins
  - Local, on-site stormwater detention basins
  - Bridge and culvert replacement
  - Channel improvements and levees
  - Floodplain management program
  - Flood warning system

- *All jurisdictions will provide improvements, such as detention basins and drainage channels, within their boundaries to control local drainage problems.* This flood control plan addresses regional, not local flooding problems, where regional means problems that are a result of runoff from one or more major subbasins (areas greater than 200 acres).

- *Where bridge and culvert improvements are recommended, the design capacities were calculated assuming no other mitigation measures were in effect.* This assumption was necessary because it was not possible to know when or if regional detention basins and other mitigation measures will be constructed.

FINDINGS

The following paragraphs contain a summary of the principal findings of this study.

1. *Substantial flood damages will occur with the 100-year flood under existing conditions.* Areas with the most extensive and frequent damages include areas along Miners Ravine in the vicinity of Joe Rodgers Road and upstream of Sierra College Boulevard; Paragon Court near Antelope Creek in Rocklin; areas along Cirby, Linda and Dry Creeks in Roseville; and along Dry Creek in Rio Linda. Some of these same areas are susceptible to flooding from storms as frequent as the 10-year storm.

2. *The magnitude of the potential peak flood flow increases due to development will vary throughout the watershed, but will average 10 to 20 percent.* In areas where extensive development is planned, flows may increase up to 30 percent, while some areas with little or no future development will have an insignificant increase in flow.

3. *Many of the bridges and culverts in the watershed are inadequate to pass the 100-year (70%) and even 25-year (52%) flows for both existing and future conditions.* In most cases, the flood flows will back up upstream of the bridge or culvert and will then flow across the roadway, interfering with traffic and emergency services. This flow can also damage the road embankment and bridge or culvert structure and endanger motorists. Flood damages can occur to structures upstream of the bridge due to the increased water levels.

4. *Local or on-site detention basins, while effective in reducing local flooding problems due to development, cannot completely mitigate the cumulative impact of future development in the watershed.* The implementation of on-site detention for all new development will eliminate increased flows just downstream of each detention basin. However, flows on major streams throughout the watershed will increase. It is estimated that these watershed-wide flow increases due to new development will be reduced by 55% if local detention basins are constructed with all new development.

   There are certain areas in the watershed where on-site detention will not be effective in reducing flows in the major streams and in fact may aggravate existing problems. Areas in which on-site detention is recommended are shown in Figure 5-2.

5. *Regional detention basins can be effective in reducing existing flooding problems and in mitigating future problems.* A total of 25 possible sites for regional detention basins were analyzed. Of these sites, seven sites provided the most effective flow reduction versus cost, and were included in the flood control plan. Some of the other sites could provide cost effective detention storage if, after additional study, any of the primary sites are later determined to be infeasible. The combination of local and regional detention basins will result in over 30 percent reduction in watershed-wide peak flows.

6. *Any significant clearing of the vegetation in floodplains and channels in the watershed will cause an overall increase in the magnitude of flood flows throughout the watershed.* Local exceptions should occur only where inadequate channel and/or floodplain capacity is currently causing flood damages along the stream. Other than these few exceptions, channel clearing should be prohibited throughout the watershed. Any filling in the stream channel or floodplain may also cause local flooding due to increased water surface elevation.

7. *Channel improvements and levees are proposed by other jurisdictions to solve existing and future problems along Cirby, Linda, and Dry Creeks in Roseville, and along Dry Creek in Rio Linda.* The cost and effectiveness of these measures need to be weighed against the cost and effectiveness of the regional detention basins.

8. *No mechanism currently exists in the watershed to fund regional flood control projects that remedy existing problems.* The Placer County Flood Control and Water Conservation District has the authority to make the needed improvements, but no existing source of funds to pay for those improvements.

9. *The District needs to collect fees for the service it provides.* Implementation of ongoing rates and charges or a benefit assessment would be appropriate to fund a reasonable level of service from the District. This would include system operation and maintenance, a flood warning system, monitoring, engineering studies and designs, water quality studies, water quality sampling and analysis, selected capital improvements, right-of-way purchases, a contingency fund, and District administration.

10. *New development should pay its share.* A flood control development fee assessed against each developing property would offset the flood control costs attributable to new development

RECOMMENDED PLAN

The following paragraphs describe the elements of the recommended flood control plan for the Dry Creek Watershed.

Structural Alternatives

1. *Regional Detention.* The design and construction of regional detention basins should be funded as soon as possible to reduce existing flooding problems and to help prevent future problems. Regional detention basins are designed to reduce flooding on major streams in the Dry Creek watershed. Seven specific sites have been identified. Construction of regional detention basins at these sites will reduce the 100-year future flows at Vernon Street in Roseville by nearly 30 percent. These detention basins would temporarily store close to 1,800 acre-feet of stormwater and then would release it back into the system over a period of time. Five of the basin sites are located on land that is already owned or controlled by public agencies and it was assumed that land acquisition costs will not be an issue at those sites. The total cost of the seven regional detention basins is estimated to be around $12,200,000.

   The regional detention basins require substantial further analysis, including feasibility and environmental impact studies. These further studies should be conducted as quickly as possible so that alternative sites for regional detention basins may be chosen if necessary.

   Funding for the regional detention basins will have to come from at least two different sources because they will help to reduce both existing and future flooding problems. The cost to build that portion of the regional detention basins needed to mitigate increased flows due to development, is $5,100,000, and should be funded by new development. The rest of the funding will need to come from all residents of the watershed

   The regional detention basins proposed as a part of this plan will reduce the flows that must be conveyed through both the SAFCA and City of Roseville projects. New development in the City of Roseville and in Sacramento County in the Dry Creek watershed should participate in funding regional flood control improvements such as the regional detention basins. Funds collected from new development will not be adequate to pay the entire cost of the recommended regional improvements. Roseville and SAFCA may find it is cost effective to invest more in the construction of the regional detention basins than simply that portion funded by new development. This would expedite construction of the regional detention basins and could reduce the extent of the improvements needed in the City of Roseville and in Sacramento County. Conversely, if for some reason some ar all of the regional detention basins are not built, then the funds planned for those basins should be used to help fund downstream improvements in Roseville and Sacramento County.

2. *Channel Improvements, Levees, and Floodwalls.* Local channel improvements and levees or floodwalls are recommended for three locations. Two of the locations, Cirby, Linda, and Dry Creeks in Roseville, and Dry Creek in Rio Linda are currently under study by other jurisdictions. The other location, Miners Ravine in the area of Joe Rodgers Road is addressed as part of this plan.

   - *Placer County Joe Rodgers Road Project.* Channel improvements along Miners Ravine for a distance of around 2,200 feet, along with the replacement of one bridge and the installation of a floodwall, are necessary to prevent the repeated flooding of structures that are located in the floodplain and provide protection up to the 100-year flood level. The cost estimate for this work is around $400,000. Because this is an existing problem, the majority of the funding will have to come from existing development. However, 21 percent of the required improvements, costing $92,000 will be a result of upstream development. This portion should be funded by new development.

- *City of Roseville Channel Improvement Project.* Substantial flood damages occur adjacent to streams within the City of Roseville. The City is currently designing channel improvements to reduce this flooding. The cost estimate, provided by the City of Roseville for this project, is around $12,400,000.

- *SAFCA, Rio Linda Channel Improvement and Levee Project.* The Sacramento Area Flood Control Agency (SAFCA) is currently planning channel improvements and the raising of levees to reduce the flooding that occurs along Dry Creek from the Sacramento County line to its intersection with the Natomas East Main Drainage Canal. The cost estimate provided by SAFCA for this project, is $44,600,000. This project is funded entirely by federal, state, and Sacramento County funds.

3. *Bridge and Culvert Replacement.* Replacement of bridges and culverts is designed to protect public facilities and safety by preventing flow over the top of a bridge or culvert. Replacement of the bridge or culvert will prevent flooding in the local areas around the bridge. Because of the large number (over 130) of inadequate bridges and culverts in the watershed, specific bridges and culverts were selected for replacement by each jurisdiction. A total of 42 bridge culvert sites were selected for immediate replacement on the basis of possible loss of life, emergency access, and potential damage to the inadequate structures. Privately owned structures were excluded from consideration. A list of these structures and their estimated replacement costs are found in Chapter 5, with the total cost being approximately $7,641,200.

Nonstructural Alternatives

1. *Local, On-site Detention.* Local, on-site detention facilities are recommended for all future developments in the Dry Creek watershed, except for developments in those areas indicated on Figure 5-2 as not recommended. These local detention facilities should be designed to reduce post- development flows from the 2- through 100-year storms to pre-development levels. Local detention facilities are not recommended for developments in all areas that are downstream of and include the City of Roseville, except where needed to solve local tributary flooding problems.

   It is understood that in many cases suitable sites that would allow a particular development to collect and store stormwater before release into a major stream, are not available. In these cases the developer will instead contribute an in-lieu of local detention fee to a fund that will be used to construct off-site local detention basins, improve the local conveyance facilities, and/or construct regional detention facilities to replace the local, on-site detention that was not constructed.

   Adequate maintenance of the local detention basins is essential if they are to maintain their effectiveness in reducing peak flows. A means must be found to ensure that the local detention basins are maintained adequately.

2. *Floodplain Management.* Continuing enforcement of floodplain management ordinances, grading ordinances, and policies to control development in the floodplain

and prevent modification of natural channels or removal of vegetation is needed. Local jurisdictions are urged to both adopt watershed-wide policies and ordinances and provide staff review and enforcement capabilities.

Changes in the natural channel of major streams and/or the removal of existing vegetation in their floodplains can substantially increase downstream flood flows. Prohibitions against channel and floodplain modification are stated in most general plan policies; however, these policies are not believed to be fully enforceable and are not fully enforced at the present time. Flooding problems can also be exacerbated by modifications of minor tributary channels and their floodplains.

- *Floodplain Mapping.* It is recommended that a floodplain mapping program be instituted to help prevent future damages by accurately delineating floodplains in which no building is allowed. There are around 100 stream miles in the watershed for which a program should be implemented to provide periodic updates of the 100-year floodplains. New information, such as that developed through the data collection system described above, will make it advantageous to revise floodplain estimates. This needs to be done by the District because flows under future conditions should be the basis for floodplain management, not the current conditions as used by FEMA for their floodplain mapping efforts. If these floodplain studies are conducted on a 10-year cycle, that is doing one-tenth of the streams each year, the annual cost will be around $175,000 per year.

- *Channel and Floodplain Clearing.* Control of channel and floodplain clearing throughout the watershed is an important facet of the recommended plan. Clearing channels and floodplains of the existing vegetation will increase flood flows downstream. The dense vegetation in the channels and floodplains throughout the watershed acts as a flood retarding structure. It is recommended that floodplain management and grading ordinances and policies be enacted where such ordinances and policies are not already in place. These ordinances should restrict the removal of riparian vegetation from the channels and floodplains of major streams in the Dry Creek watershed except where removal and maintenance is required to solve existing local flooding problems.

3. *Regional Flood Warning and Data Acquisition System.* A regional flood warning and data acquisition system should be implemented immediately to provide reliable flood warnings in the Dry Creek Watershed. This will greatly reduce the likelihood of personal injury or death due to flooding and will also help to reduce personal property losses. The regional system should use the existing ALERT flood warning system operated by the City of Roseville and Sacramento County and should enlarge and enhance the system to give reliable coverage for the entire Dry Creek Watershed. The estimated installation cost for the recommended system improvements and additions is $67,500 with an annual maintenance and operation cost of $60,000.

   The system will also collect data that will be vital for monitoring the effectiveness of flood control measures that are developed as a result of this plan. The data collected by the flood warning system will also provide a record on which to base further calibration of the hydrologic model of the watershed and future flood control plans and measures.

   Funding of the installation and operation of the flood warning system should be through District user fees.

4. *District Rates and Charges.* The Placer County Flood Control and Water Conservation District should collect fees to fund flood control services. These fees should be collected either as a benefit assessment or as rates and charges for services. Revisions to the District's enabling legislation may be needed before rates and charges can be used as a major funding source. The rates and charges should be set at a level to collect 3.4 million dollars annually. This includes ongoing services and debt service on capital improvements. The ongoing services include maintenance, engineering, insurance, floodplain map revisions, flow monitoring, and water quality studies. The capital improvements costs are the ones which cannot be allocated to new development. Billing rates should vary based on a properties land use, location and size. Initial recommended billing rates for single family homes vary from $63 per house per year in the main stem drainage area to a high of $171 per house per year for homes in the Miners Ravine watershed.

5. *Funding for Flood Control Services Related to New Development.* A total of 7.4 million dollars should be collected from new development in the Dry Creek Watershed to fund regional flood control capital improvements necessitated by that development. The simplest way to collect those funds would be through a development fee. That development fee should vary based on the property use, location and size. Recommended single family home development fees vary from $152 per house to $480 per house.

CHAPTER 1
INTRODUCTION

PURPOSE

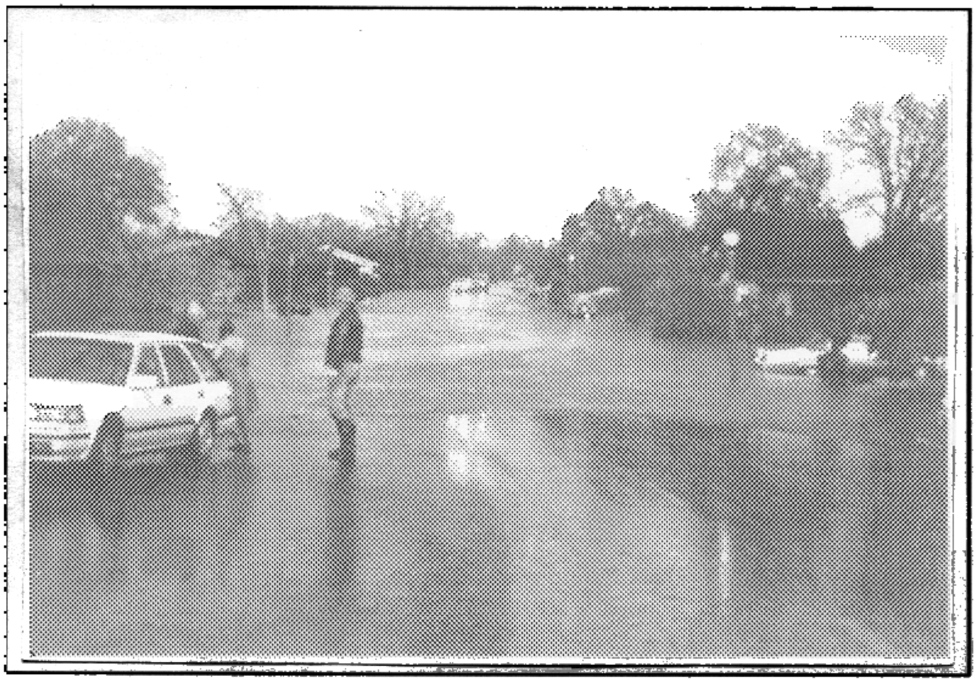
Incidences of flooding along Dry Creek and its tributaries (Antelope Creek, Clover Valley Creek, Secret Ravine, Miners Ravine, Strap Ravine, Linda Creek, and Cirby Creek) are well documented. Flooding occurs when heavy rains cause streams to overflow their banks, flooding property and structures located adjacent to the stream. Streams also back up at culverts and bridges, blocking roads or making them unsafe. Figures 1-1 and 1-2 are photos of flooding that occurred in the Dry Creek Watershed during the February 1986 flood. Emergency services can also be restricted by the flooded roads. Officials and elected representatives in both Placer and Sacramento Counties are concerned, not only with existing problems, but also with future problems that can result from the development occurring in the area. Continued development in both the upper and lower reaches of the watershed will only make the flooding problems worse unless adequate steps are taken to plan and implement comprehensive watershed-wide solutions to the drainage problems.

Satisfactory solutions to the flooding problems in the Dry Creek watershed cannot be provided on a site by site basis because of the possible adverse downstream impacts of any proposed solution. These downstream impacts must be taken into consideration when planning flood control projects and setting flood control policies. The purpose of the Dry Creek Watershed Flood Control Plan is to provide the Placer County Flood Control and Water Conservation District and other governmental agencies in both Placer and Sacramento Counties with the information and policies necessary to manage the storm waters within the Dry Creek watershed. It also includes consideration of required improvements and the associated funding programs to accomplish the improvements. This Flood Control Plan is intended to provide an approach for meeting existing and future flood control needs in Dry Creek watershed. Implementation of the plan will require additional detailed planning, design, and Environmental Impact Review.

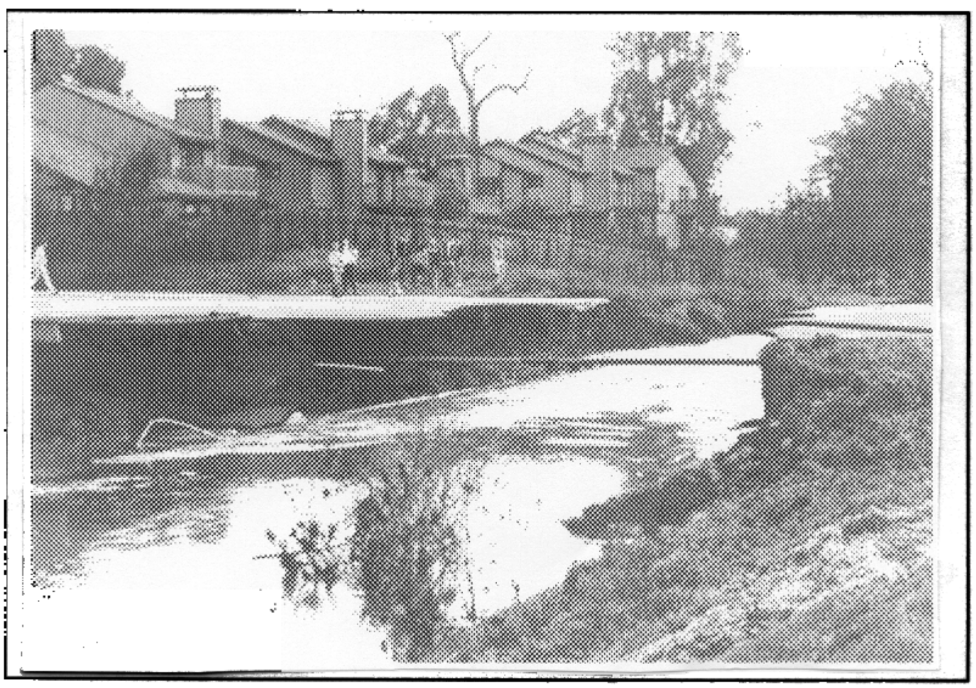
WATERSHED DESCRIPTION

The Dry Creek watershed covers about 101 square miles in Placer and Sacramento Counties. A map showing the entire watershed is given in Figure 1-3, Area Map. The Area Map in Figure 1-3 also shows the watershed and subbasin boundaries that were used in developing the model. Rectangles, representing detailed map coverage, are shown on the Index Map, Figure 1-4.

The headwaters of Dry Creek are located in the upper portions of the Loomis Basin, in the vicinity of Penryn and Newcastle, in unincorporated Placer County, in the Granite Bay area near Folsom Lake, and in Orangevale in Sacramento County. Antelope Creek and Clover Valley Creek form the northwest boundary of the watershed, and Secret Ravine and Miners Ravine comprise the northeast portion of the watershed. Antelope Creek and Miners Ravine, after combining with Clover Valley Creek and Secret Ravine, respectively, combine near Interstate 80 and Atlantic Street in Roseville to form Dry Creek. Cirby Creek, made up of the combination of Cirby and Linda Creeks and Strap Ravine, joins Dry Creek just upstream of Riverside Avenue in Roseville. Downstream of Roseville, just downstream of Elverta Road, Dry Creek branches into North Dry Creek and Dry Creek and forms Cherry Island in the Rio Linda area.



CHAMPION OAKS DRIVE, FEBRUARY 1986
FIGURE 1-1



ROCKY RIDGE ROAD CULVERT WASHOUT
FIGURE 1-2

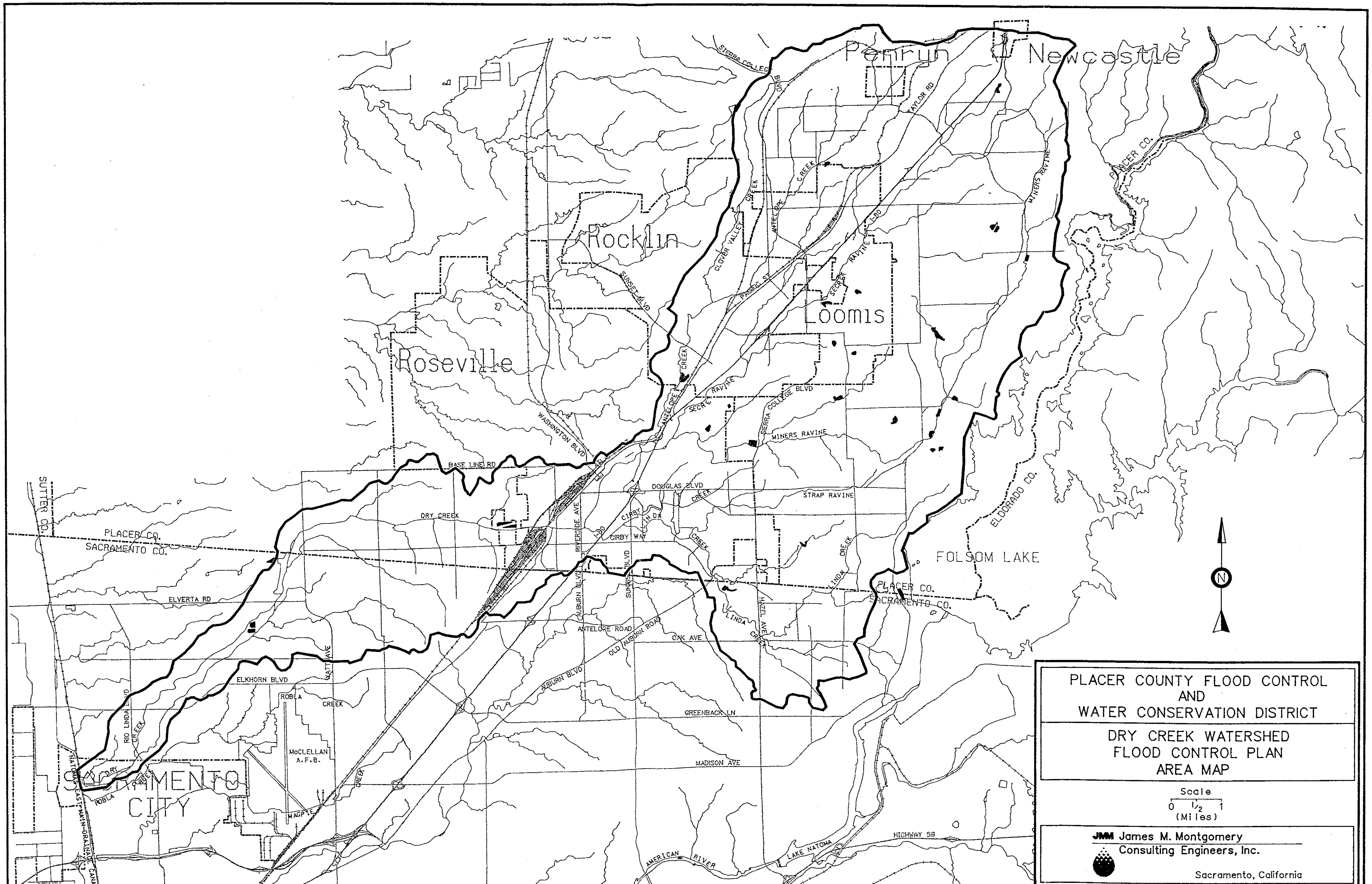

PLACER COUNTY FLOOD CONTROL
AND
WATER CONSERVATION DISTRICT
DRY CREEK WATERSHED
FLOOD CONTROL PLAN
AREA MAP
Scale
0 1/2 1
(Miles)
JMM James M. Montgomery
Consulting Engineers, Inc.
Sacramento, California
Penryn
Newcastle
Rocklin
Loomis
Roseville
FOLSOM LAKE
SACRAMENTO CITY
PLACER CO.
SACRAMENTO CO.
SUTTER CO.
ELDORADO CO.
McCLELLAN A.F.B.
N

FIGURE 1-3

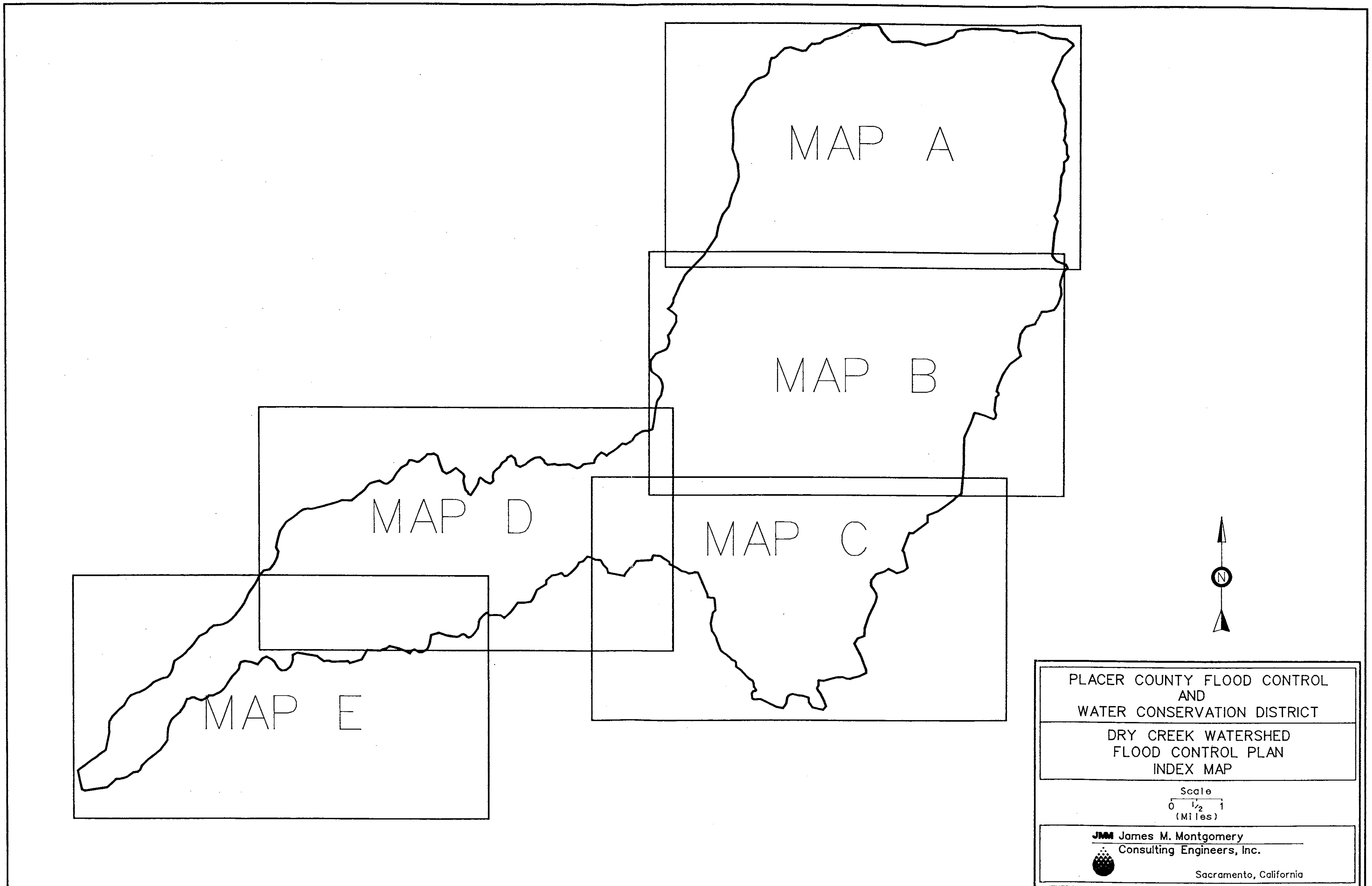

MAP A
MAP B
MAP C
MAP D
MAP E
N
PLACER COUNTY FLOOD CONTROL
AND
WATER CONSERVATION DISTRICT
DRY CREEK WATERSHED
FLOOD CONTROL PLAN
INDEX MAP
Scale
0 1/2 1
(Miles)
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FIGURE 1-4

Topography

The lower end of the Dry Creek watershed is on the Sacramento Valley floor and the headwaters are located in the Sierra Nevada foothills. The mouth of Dry Creek, at its confluence with the Natomas East Main Drainage Canal, is at an elevation of about 30 feet, above mean sea level (msl). Antelope Creek, Secret Ravine, and Miners Ravine have headwaters in the vicinity of Newcastle and Penryn at elevations of 900 to 1200 feet, msl, in hilly topography typical of the foothills. Linda Creek, Cirby Creek, and Strap Ravine have headwaters in Orangevale in Sacramento County, and in the Granite Bay area at elevations of 300 to 500 feet, msl with less relief than is found in the other Dry Creek tributaries.

The upper portions of the Dry Creek watershed are characterized by relatively steep slopes and moderate relief. The lower reaches of the Dry Creek watershed, especially downstream of Roseville, are characterized by very gentle slopes. The stream channels throughout the watershed are generally well defined, but are not especially wide or deep.

Soils

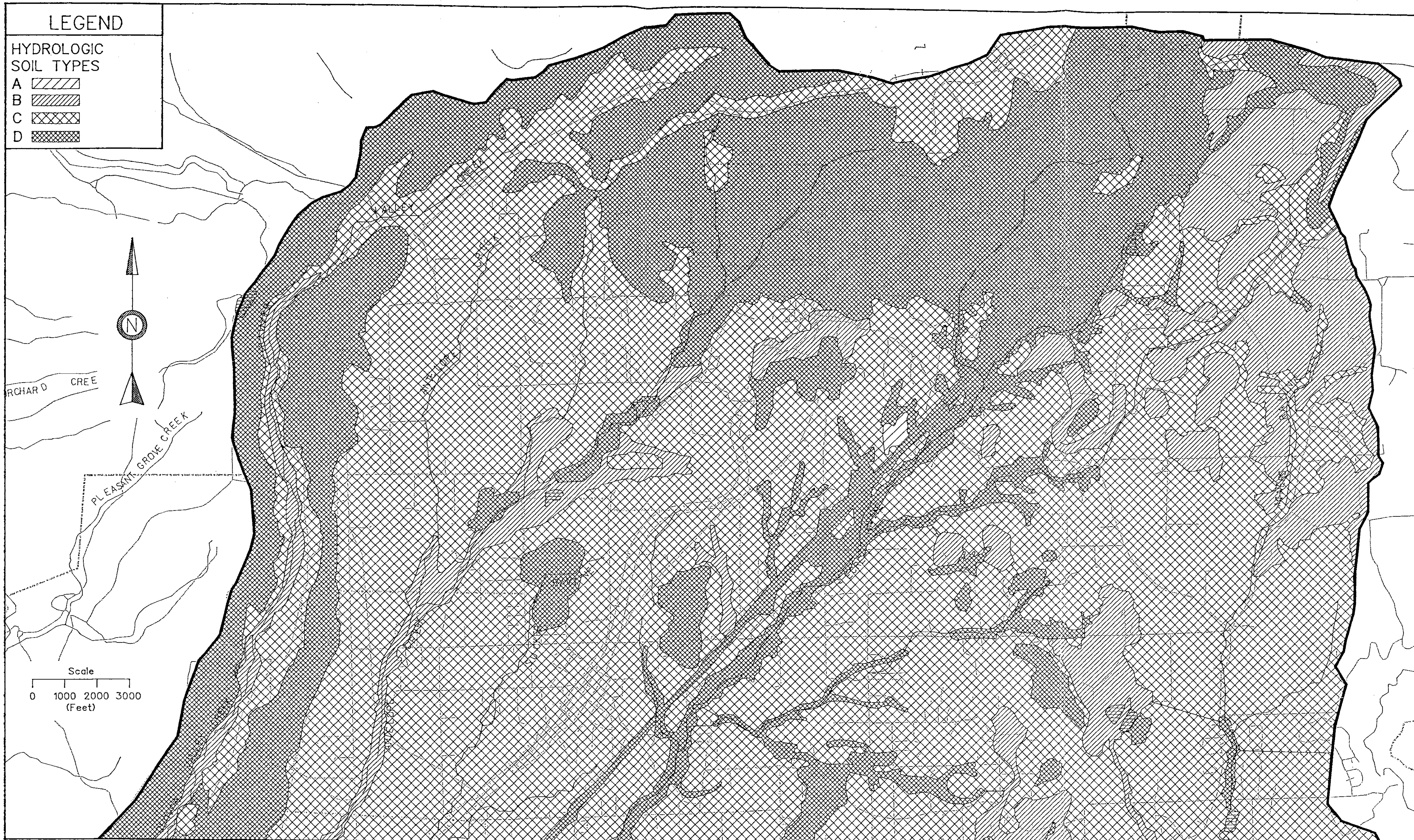
Soils in the watershed have been given hydrologic classifications by the Soil Conservation Service (SCS) in TR-55 and other publications. These classifications divide the soils based on infiltration rates and are:

- Group A - Low runoff potential. Soils having high infiltration rates even when thoroughly wetted and consisting chiefly of deep, well- to excessively-drained sands or gravels.
- Group B - Moderately low runoff potential. Soils having moderate infiltration rates when thoroughly wetted and consisting chiefly of moderately deep to deep, moderately well to well-drained soils with fine to moderately coarse textures. These soils have a moderate rate of water transmission.
- Group C - Moderately high runoff potential. Soils having slow infiltration rates when thoroughly wetted and consisting chiefly of soils with a layer that impedes downward movement of water, or soils with moderately fine to fine texture. These soils have a slow rate of water transmission.
- Group D - High runoff potential. Soils having very slow infiltration rates when thoroughly wetted and consisting chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very slow rate of water transmission.

Figures 1-5a to 1-5e are maps showing the distribution of the various hydrologic soil types occurring throughout the Dry Creek watershed.

Land Use

The types of land use that occur in a watershed are very significant in determining the amount of runoff that results from a given amount of rainfall. Much of the difference in runoff from different land uses can be attributed to the difference in the percentage of the land that is impervious (paved or covered by buildings) for each land use type. Another important factor that is determined by the type of land use is the condition, or hydraulic efficiency, of the smaller tributaries and streams in an area. For example, an area that is mostly rural



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PLACER COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT

DRY CREEK WATERSHED
HYDROLOGIC SOIL TYPES
MAP A

FIGURE 1-5A

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PLACER COUNTY FLOOD CONTROL
AND
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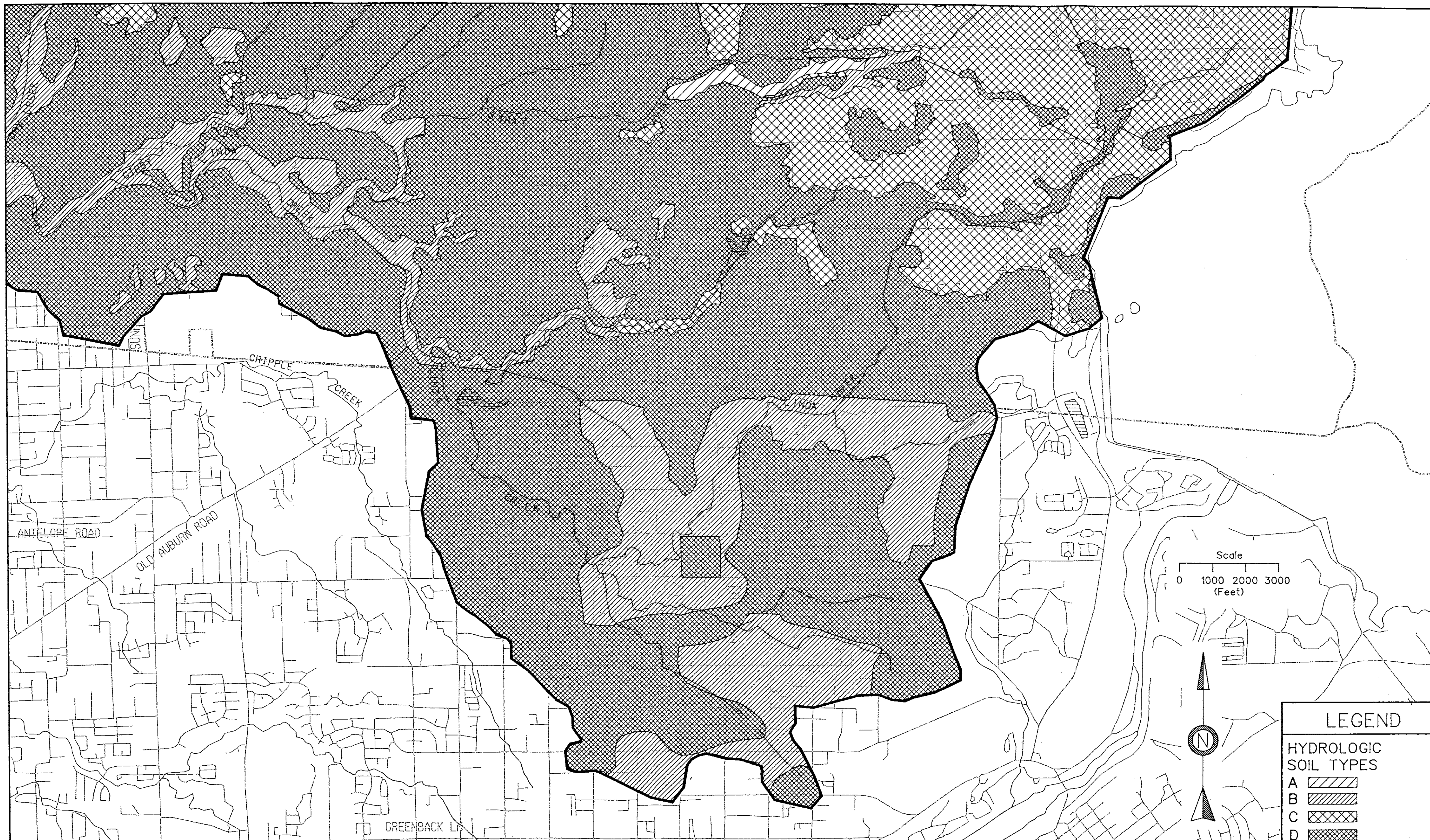
DRY CREEK WATERSHED
HYDROLOGIC SOIL TYPES
MAP B

FIGURE 1-5B



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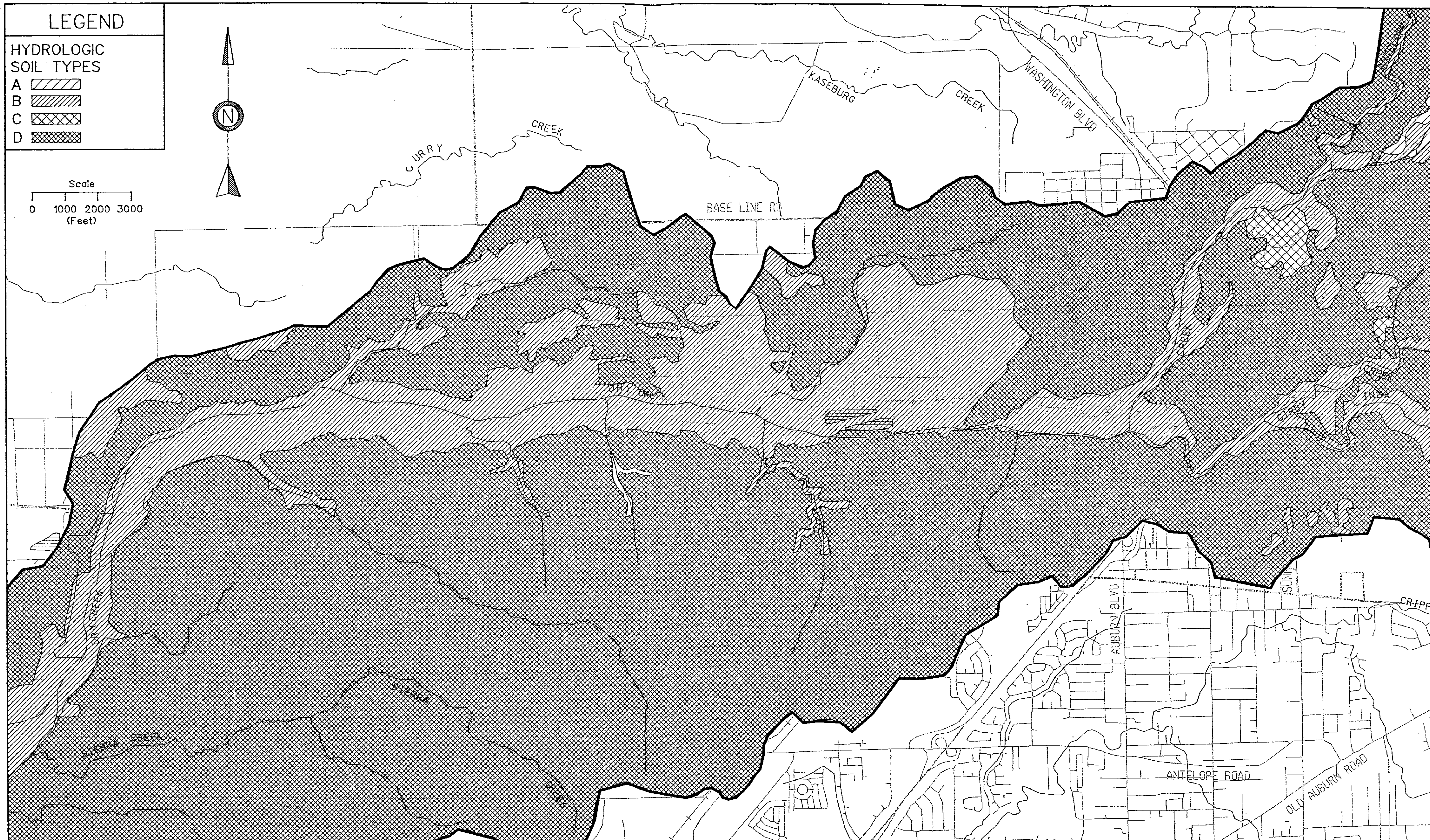
PLACER COUNTY FLOOD CONTROL
AND
WATER CONSERVATION DISTRICT

DRY CREEK WATERSHED
HYDROLOGIC SOIL TYPES
MAP C

FIGURE 1-5C



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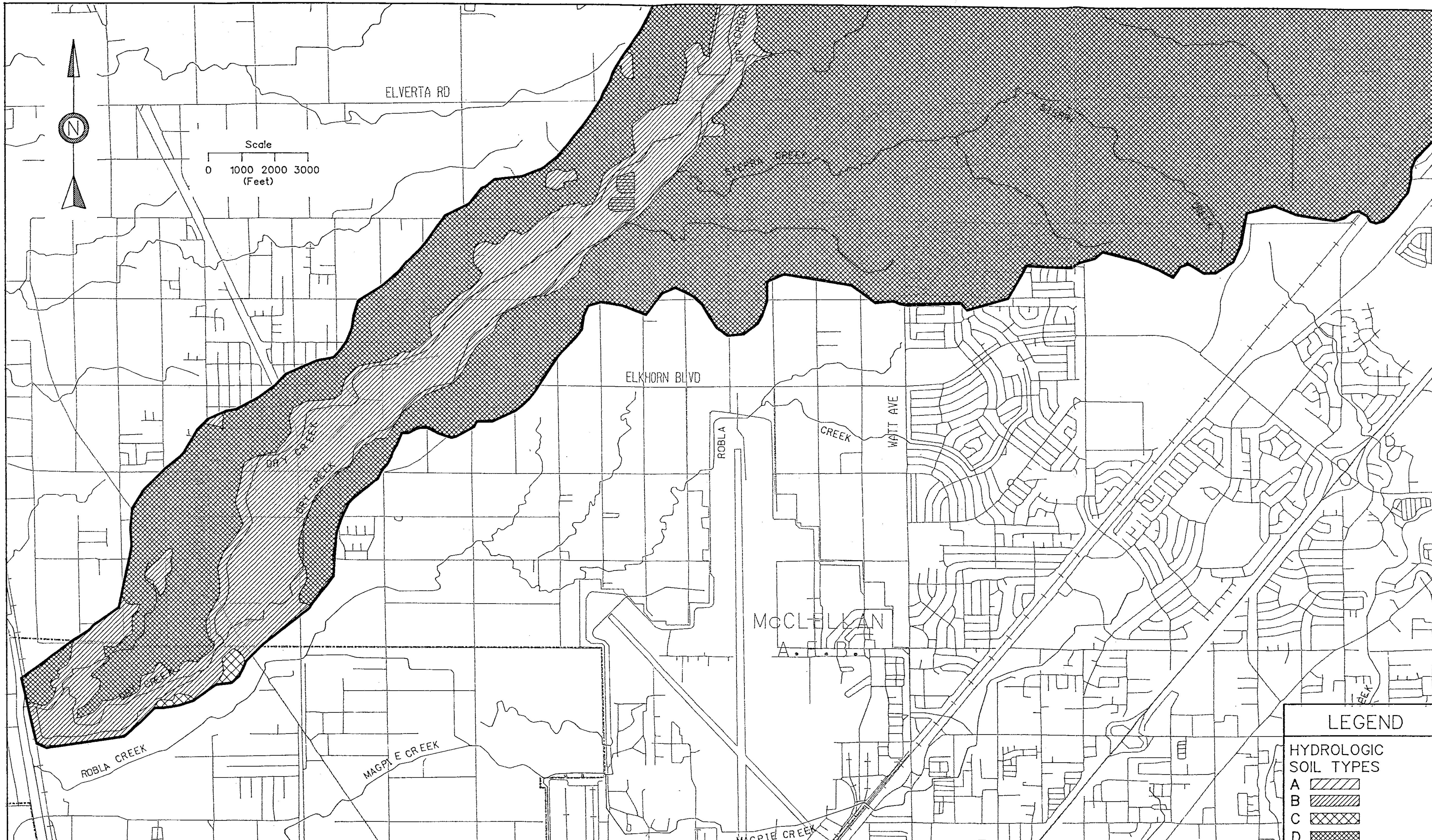
PLACER COUNTY FLOOD CONTROL
AND
WATER CONSERVATION DISTRICT

DRY CREEK WATERSHED
HYDROLOGIC SOIL TYPES
MAP D

FIGURE 1-5D



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PLACER COUNTY FLOOD CONTROL
AND
WATER CONSERVATION DISTRICT

DRY CREEK WATERSHED
HYDROLOGIC SOIL TYPES
MAP E

FIGURE 1-5E

residential will have streams that are largely in their natural state, with relatively inefficient hydraulic properties. This results in a slower and less intense concentration of runoff from the area. In comparison, the small tributary streams in a commercial area will most likely be improved if not actually piped. This improvement in the efficiency of the hydraulic properties causes the runoff in those tributary streams to reach the main streams and combine together more quickly, producing a faster and more intense concentration of runoff from the area.

The land use in the Dry Creek watershed varies widely, from agricultural, to residential, to commercial. Table 1-1 contains a listing of the land use categories used in this plan.

General plans have been developed by the various government entities in the Dry Creek watershed and indicate the current planning for development in the watershed. The general plans used to develop the land use for this study are:

- Granite Bay Community Plan (1989)
- Town of Loomis General Plan (1975)
- Loomis Basin General Plan (1986)
- City of Rocklin General Plan (1978)
- Dry Creek West Placer Community Plan (1989)
- City of Roseville General Plan (1988)
- Sacramento County General Plan (1990)

Figures 1-6a to 1-6e indicate the watershed land uses, utilized in this plan, that have been derived from the general plans for the different areas in the Dry Creek watershed.

TABLE 1-1

GENERALIZED LAND USE CODES

Code	Description	Definition
COMM	Commercial, Professional, Industrial, Highways	Self explanatory
HDR	High Density Residential	4-10 Dwelling Units/Acre
MDR	Medium Density Residential	2-4 Dwelling Units/Acre
LDR	Low Density Residential	0.4-0.9 Acre Minimum
RLDR	Rural Low Density Residential	0.9-2.3 Acre Minimum
RR	Rural Residential	2.3-5 Acre Minimum
RE	Rural Estates	5-20 Acre Minimum
OS	Open Space (undeveloped)	Self explanatory

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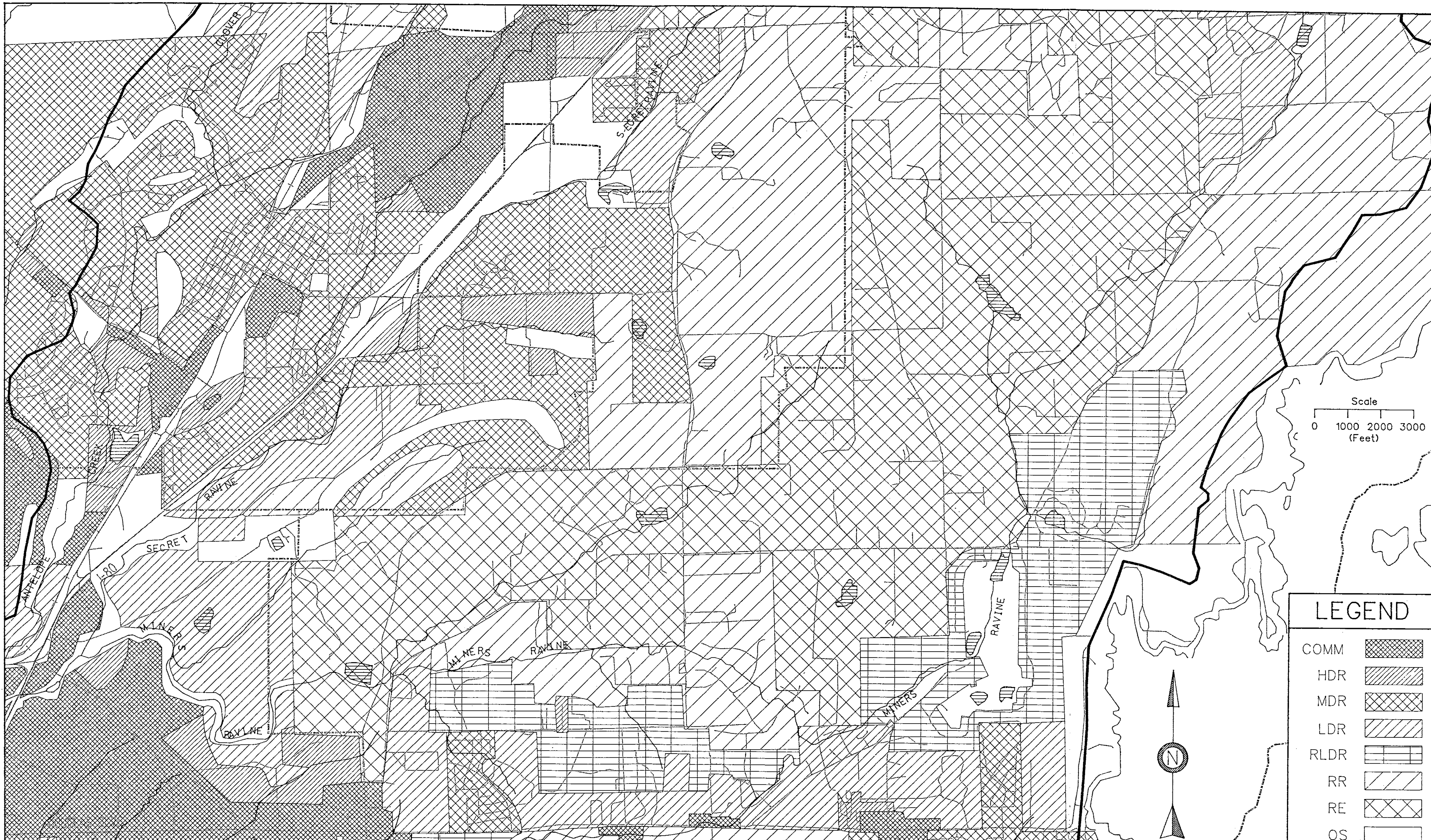
PLACER COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT

DRY CREEK WATERSHED GENERAL PLAN LAND USE MAP A

FIGURE 1-6A



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PLACER COUNTY FLOOD CONTROL
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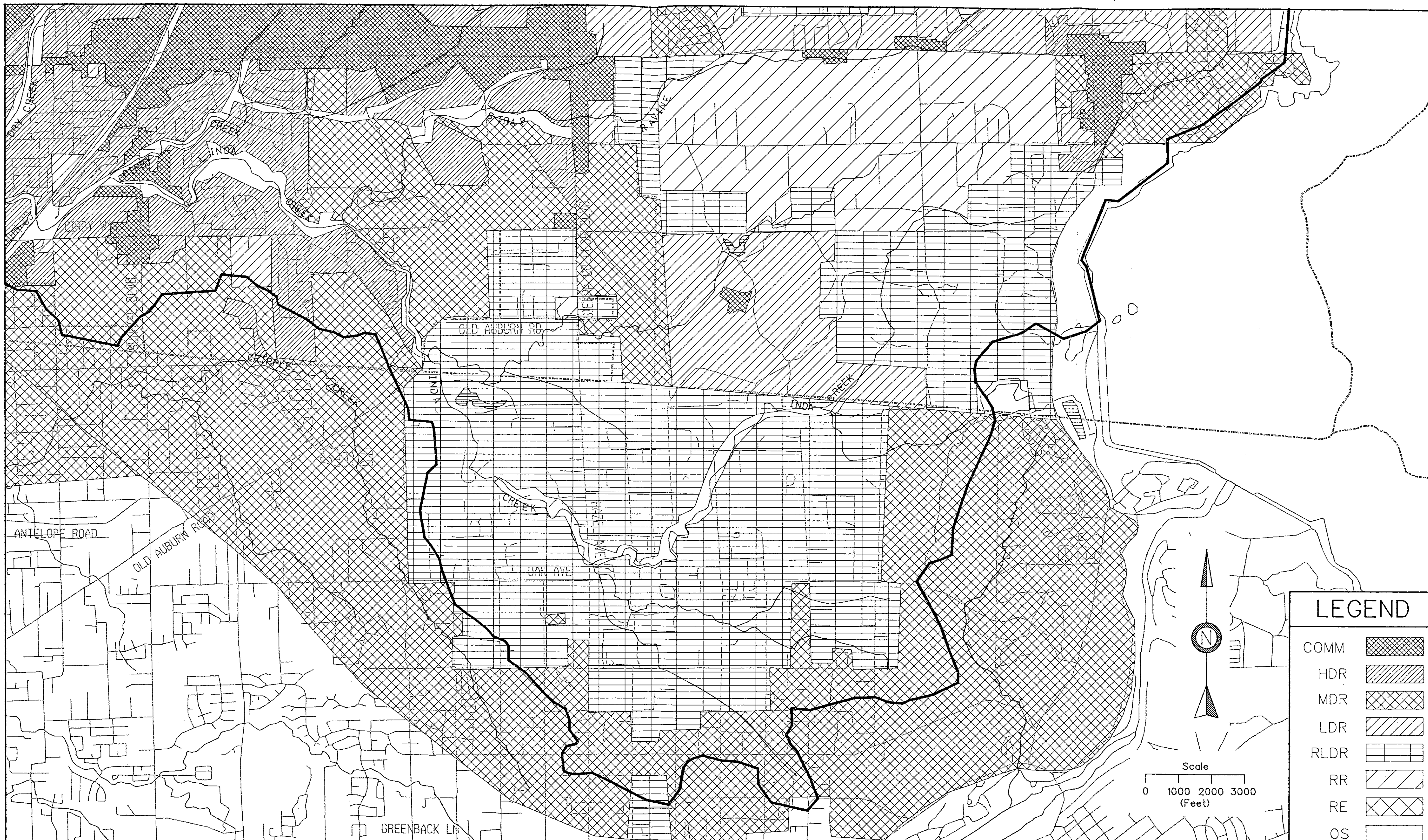
WATER CONSERVATION DISTRICT

DRY CREEK WATERSHED
GENERAL PLAN LAND USE
MAP B

FIGURE 1-6B



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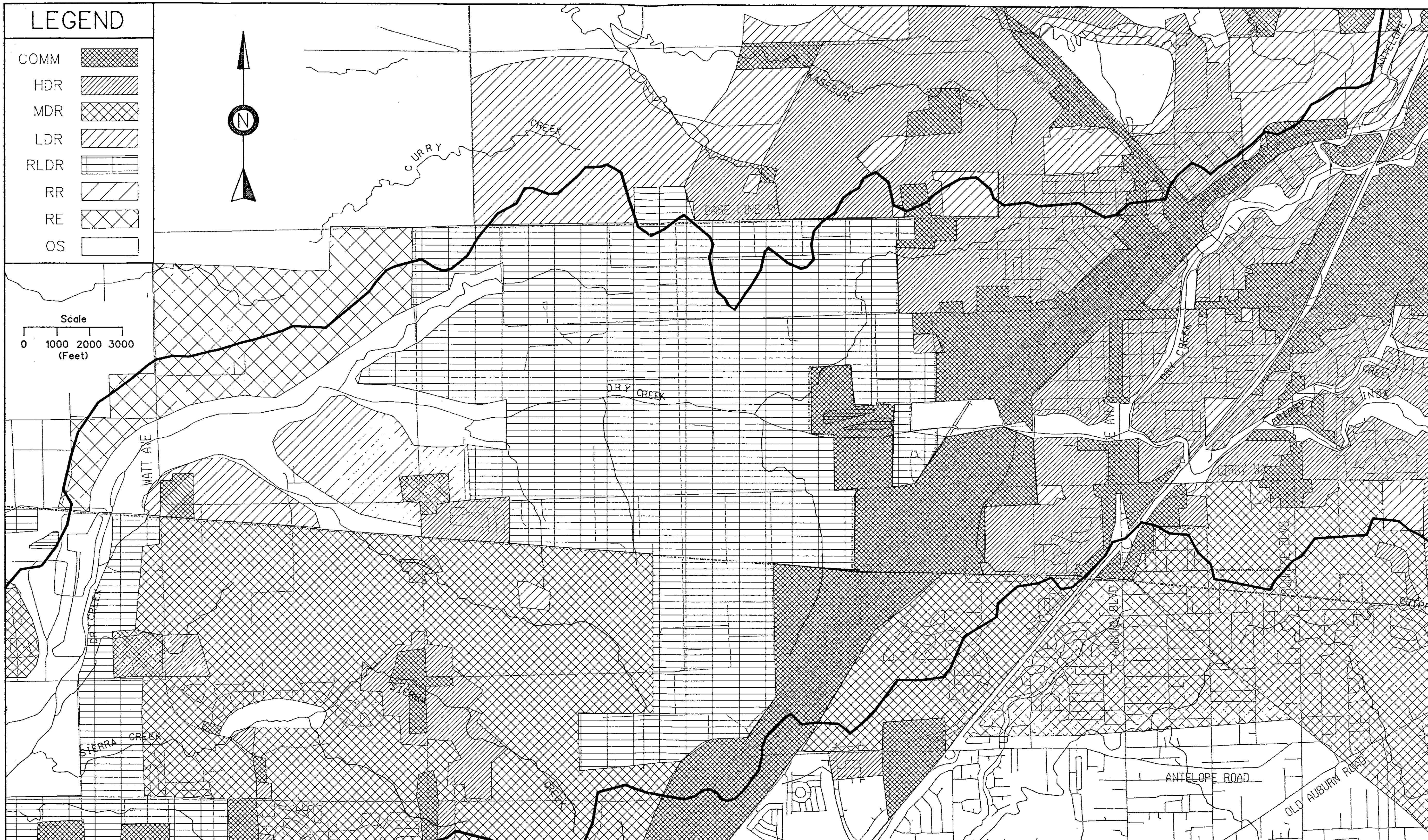
PLACER COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT

DRY CREEK WATERSHED GENERAL PLAN LAND USE MAP C

FIGURE 1-6C



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PLACER COUNTY FLOOD CONTROL
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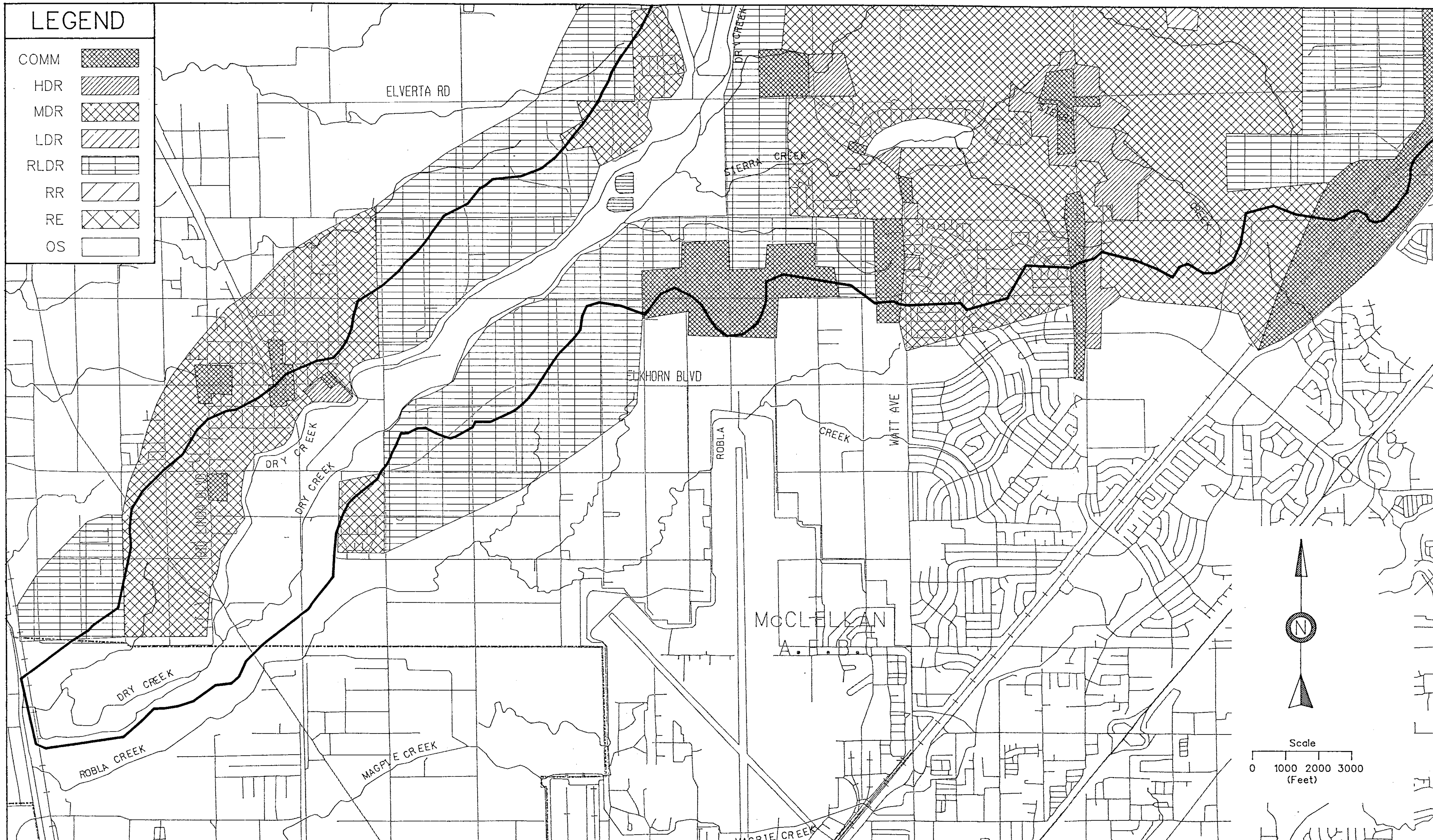
DRY CREEK WATERSHED
GENERAL PLAN LAND USE
MAP D

FIGURE 1-6D



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PLACER COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT

DRY CREEK WATERSHED
GENERAL PLAN LAND USE
MAP E

FIGURE 1-6E

Because current aerial photography of the watershed was not available at the beginning of the study (June 1990), existing land use was determined from aerial photographs taken in the summer of 1989, correlated with land use designation data from the current general plans. This land use was used as the base condition for the model. Except for a few local areas, land use in the watershed was not significantly different between summer 1989 and spring 1990. Future land use was determined from the current general plans for the various areas in the watershed. Total impervious area for the watershed, based on the procedures described in Chapter 2, is estimated to be 14 and 22 square miles for 1989 and Future condition land use respectively.

Development History

The Dry Creek watershed is located in an area that has and is experiencing rapid urbanization and population growth. The population in this area increased by more than 65 percent from 1970 to 1985, an annual growth rate of 3.4 percent. During the same period the state's population increased by 30 percent, highlighting the rapid growth that has taken place in the watershed. In 1989, this area experienced a growth rate of over five percent, which was the fastest in the state, and this trend is likely to continue. At an annual growth rate of four percent, the currently approved general plans in Placer County will be built out by the year 2001.

DESCRIPTION OF HISTORIC FLOOD DAMAGE

Floods in the Dry Creek watershed have occurred from October through April. The floods are generally caused by a combination of prolonged rainfall leading to saturated soils, and a short period of one to six hours of intense precipitation associated with frontal convection or severe thunderstorms.

Dry Creek and its tributaries have an extensive record of historic floods, especially in the Roseville area. Streamflow records are available for a gage in Roseville beginning in 1950. Damaging floods occurred in December 1955, April 1958, October 1962, December 1964, March 1983, and February 1986. The floods of 1983 and 1986 are the largest and most damaging on record. Hydrologic studies have shown that the recurrence interval of the March 1983 flood was approximately 10 years and the recurrence interval of the February 1986 flood was from 50 to 100 years depending on the specific location in the Dry Creek watershed.

The March 1983 flood damaged approximately 25 residences along Linda and Cirby Creeks in Roseville. Portions of Royer Park were under water as well as areas in the Sierra Lakes Mobile Home Park. Dry Creek overflowed the Darling Way and Riverside Avenue bridges, disrupting traffic and flooding six businesses along Riverside Avenue.

The February 1986 flood caused widespread damage in most of the Dry Creek watershed. Nearly all bridges and culverts were overtopped, with 30 sustaining embankment damage and the crossing at Rocky Ridge Drive washing out. Two bridges over Dry Creek were damaged and street cave-ins occurred at a number of locations. Flooding caused the closure of many major streets in the watershed, including Riverside Avenue, Darling Way, Douglas Boulevard, Vernon Street, Sierra College Boulevard, and others.

Around 100 homes in Roseville along Dry Creek, Linda Creek, and Cirby Creek were flooded with water levels up to five feet above floor levels. Ten homes along Antelope Creek and Secret Ravine tributaries in Rocklin and around sixteen homes in Miners Ravine in Placer County, in the area of Joe Rodgers Road, were flooded. Roseville City Hall and libraries were temporarily closed when their basements flooded. Downstream of Roseville, several residences along Dry Creek in Placer County were flooded. Flooding occurred along most of Elkhorn Boulevard near Dry Creek in Sacramento County, including many residences, schools, and businesses.

INVENTORY OF STREAM CROSSINGS

Many of the problems that occur as a result of flooding are related to inadequate conveyance structures (culverts or bridges) at stream crossings. Table 1-2 lists all the stream crossings in the watershed that were examined as part of this study. Also included in Table 1-2 are other major points of interest in the watershed. The crossing number can be used to locate the stream crossing on Figures 1-7a to 1-7e.

RELEVANT PREVIOUS STUDIES

The following is a list of relevant previous studies:

- Studies by the Sacramento District, U.S. Army Corps of Engineers:
  - Flood Plain Information, Roseville, CA, Dry Creek and Tributaries, May 1973.
  - Flood Plain Information, Rocklin, CA, Antelope Creek, Secret Ravine, and Tributaries, April 1976.
  - Flood Insurance Study, Sacramento County, CA, Unincorporated Areas, September 1978.
  - Dry Creek Drainage Basin, Interim Land Use Projections 1990, 2000, 2010, 2020, and 2040, March 1984.
  - Dry Creek, Placer and Sacramento Counties, CA, Hydrology Office Report, July 1984, inclusive Supplements No. 1 and 2, Revised April 1988.
  - Dry Creek, Roseville, CA, Draft Feasibility Report and Draft Environmental Impact Statement, March 1990.
- Flood Analysis of the Roseville Basin, Philip Williams and Associates, August 1983.
- Preliminary Engineering and Design of Flood Control Alternatives for Dry Creek Interim Investigation, Leedshill-Herkenhoff, Inc., January 1985.
- Roseville Hydrology, Nolte and Associates, September 1986.
- Flood Insurance Study, Town of Loomis, CA, Placer County, FEMA, 1987.
- Flood Insurance Study, City of Roseville, CA, Placer County, FEMA, Updated July 1989.
- Benham Group Study, commissioned by Rio Linda residents.
- Flood Insurance Study, Placer County, CA, Unincorporated Areas, FEMA, Revised January 1987.
- Flood Insurance Study, City of Rocklin, CA, Placer County, FEMA, Revised September 1990.

TABLE 1-2
LIST OF STREAM CROSSINGS AND MAJOR POINTS OF INTEREST

Number	Name
	DRY CREEK
1	Rio Linda Boulevard (North and South)
2	Elkhorn Boulevard (North and South)
3	Curved Bridge Road (North and South)
4	Dry Creek Road (North and South)
5	Q Street (North)
6	Goat Creek Confluence
7	28th Street (South)
8	Elverta Road
9	Confluence County Line Tributary
11	Watt Avenue
13	Confluence with DC65 Tributary
14	Walerga Road
16	Cook Riolo Road
17	Southern Pacific Railroad Spur
18	Atkinson Boulevard
20	Southern Pacific Railroad Culverts
21	Vernon Street
22	Riverside Avenue
23	Cirby Creek Confluence
24	Darling Way
25	Douglas Boulevard
26	Royer Park Footbridge
27	Lincoln Street
28	Folsom Road
30	Antelope Creek/Miners Ravine
	DRY CREEK/ELVERTA TRIBUTARY
31	Confluence with Dry Creek
	DRY CREEK/SIERRA CREEK
32	Confluence with Dry Creek
33	28th Street
34	Scotland Drive
35	Delaney Drive
36	Watt Avenue
37	Navaho Way
38	Elverta Road
39	Walerga Road
	DRY CREEK/COUNTY LINE TRIBUTARY
40	Confluence with Dry Creek
41	Watt Avenue
42	PFE Road
	DRY CREEK/DC65 TRIBUTARY
43	Confluence with Dry Creek
44	Walerga Road

TABLE 1-2 (CONTINUED)
LIST OF STREAM CROSSINGS AND MAJOR POINTS OF INTEREST

Number	Name
	CIRBY CREEK
45	Dry Creek Confluence
46	Interstate 80
48	Wanda Lee Court Footbridge
49	Linda Creek Confluence
50	Sunrise Boulevard
51	Coloma Way
52	Oak Ridge Drive
53	Sierra Gardens Footbridge
54	Loretto Drive
55	Sierra Gardens Tributary Confluence
56	Sierra Gardens Drive
57	Huntington Drive
58	Rocky Ridge Drive
60	Winchester Way
61	Eureka Road
62	Douglas Boulevard
	CIRBY CREEK/SIERRA GARDENS TRIBUTARY
63	Cirby Creek Confluence
65	Douglas Boulevard
66	Sierra Gardens Retention Basin
	LINDA CREEK
67	Cirby Creek Confluence
68	Sunrise Avenue
70	Oak Ridge Drive
72	Sierra Gardens Footbridge
73	Rocky Ridge Drive
74	Strap Ravine Confluence
76	Champion Oaks Drive
78	Auburn Road
79	Old Auburn Road/City Limits
80	Treelake Tributary Confluence
82	Indian Creek Drive
83	Hazel Avenue
84	Orangevale Tributary Confluence
85	Granite Avenue
86	Cherry Avenue
88	Wedgewood Drive
89	East Roseville Parkway
90	Barton Road
91	Shadow Brook Place
92	Purdy Lane
93	Country Court
94	Auburn Folsom Road

TABLE 1-2 (CONTINUED)
LIST OF STREAM CROSSINGS AND MAJOR POINTS OF INTEREST

Number	Name
	LINDA CREEK/STRAP RAVINE
95	Linda Creek Confluence
96	McClaren Drive
97	Johnson Ranch Drive
98	Eureka Road
99	East Roseville Parkway
100	Sierra College Boulevard
101	Barton Road
	LINDA CREEK/TREELAKE TRIBUTARY
102	Linda Creek Confluence
103	Petite Way
104	Old Auburn Road
105	Sierra College Boulevard
106	Swan Lake Drive
107	Swan Lake
108	Waterbury Way
109	Waterbury Lake
110	East Roseville Parkway
111	East Roseville Parkway Pond
112	Treelake Office Lane
113	Treelake Office Lane Pond
	LINDA CREEK/HAZEL AVENUE TRIBUTARY
114	Linda Creek Confluence
115	Oak Avenue
	LINDA CREEK/ORANGEVALE TRIBUTARY (Sacramento County)
116	Linda Creek Confluence
117	Oak Avenue
118	Filbert Avenue
119	Chestnut Avenue
120	Walnut Avenue (North and South)
121	Main Avenue (North and South)
	ANTELOPE CREEK
122	Miners Ravine/Dry Creek
123	Harding Boulevard
124	Atlantic Street
125	County Dump Road
126	Highway 65
127	Springview Drive
128	Rocklin City Tributary Confluence
130	Sunset Boulevard

TABLE 1-2 (CONTINUED)
LIST OF STREAM CROSSINGS AND MAJOR POINTS OF INTEREST

Number	Name
133	Clover Valley Creek Confluence
134	Midas Avenue
135	Southern Pacific Railroad
136	Yankee Hill Road
137	Atchinson Dairy Dam
138	Unnamed Road
139	Delmar Avenue
140	Sierra College Boulevard
141	King Road
	ANTELOPE CREEK/CLARK TUNNEL ROAD TRIBUTARY
142	Antelope Creek Confluence
143	Barker Road
144	Humphrey Road
145	Humphrey Tributary Confluence
148	Colwell Road
149	English Colony Way
150	Clark Tunnel Road
	ANTELOPE CREEK/ROCKLIN CITY TRIBUTARY
151	Antelope Creek Confluence
152	Taylor Road
153	Taylor Road
154	Sunset Boulevard
	ANTELOPE CREEK/CLOVER VALLEY CREEK
155	Antelope Creek Confluence
156	Argonaut Avenue
157	Footbridge and Weir
158	Midas Avenue
159	Abandoned Stone Bridge
160	Unnamed Bridge
161	Clover Valley Detention Pond
162	Creekwood Drive
163	Rawhide Road
164	Rawhide Road Detention Pond
165	Unnamed Road
166	Sierra College Boulevard
167	English Colony Way
	ANTELOPE CREEK CONTINUED
169	Clark Tunnel Road Tributary Confluence
170	Barker Road
171	Citrus Colony Road
172	English Colony Way

TABLE 1-2 (CONTINUED)
LIST OF STREAM CROSSINGS AND MAJOR POINTS OF INTEREST

Number	Name
	ANTELOPE CREEK/HUMPHREY TRIBUTARY
173	Antelope Creek Confluence
174	Sandy Road
175	Mardell Lane
176	Colwell Road
177	English Colony Way
	MINERS RAVINE
178	Antelope Creek/Dry Creek
179	Harding Boulevard
180	Interstate 80
181	Eureka Way
182	Secret Ravine Confluence
183	Sunrise Avenue
184	Boardman Tributary
185	East Roseville Parkway
186	Sierra College Boulevard
187	Cavitt Stallman Tributary
188	Cavitt & Stallman Road
190	Shadow Oaks Lane
191	Barton Road
192	Tall Pine Lane
193	Carolinda Drive
194	Itchy Acres Road
196	Miners Ravine Road
197	Leibinger Lane
199	Auburn Folsom Road
200	Oak Lake
201	Old Bridge
202	Cottonwood Lake
203	Auburn Folsom Road
204	Confluence with Lake Tributary
205	Moss Lane
207	Dick Cook Road
208	Auburn Folsom Road
209	Placer Canyon Parkway
210	Horseshoe Bar Road
211	Auburn Folsom Road
212	King Road
213	Penryn Rock Springs Rd.
214	Newcastle Road
	MINERS RAVINE/BOARDMAN TRIBUTARY
215	Miners Ravine Confluence
216	East Roseville Parkway

TABLE 1-2 (CONTINUED)
LIST OF STREAM CROSSINGS AND MAJOR POINTS OF INTEREST

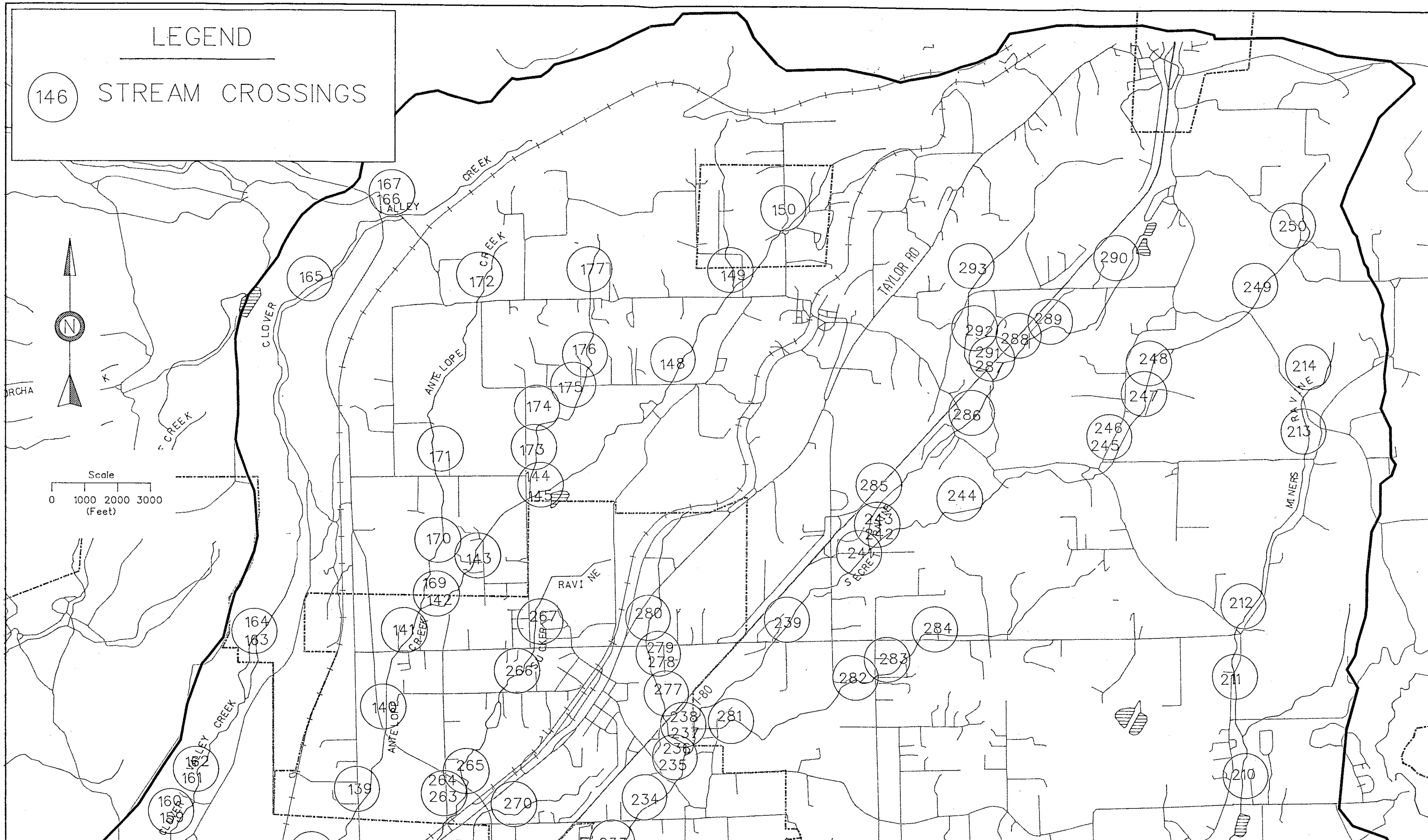
Number	Name
	MINERS RAVINE/CAVITT AND STALLMAN TRIBUTARY
217	Miners Ravine Confluence
218	Hidden Valley Place
219	Baywood Road
220	S Bar B Lane
221	Kokula Lane
222	Crestview Lane
223	Barton Road
	MINERS RAVINE/LAKE TRIBUTARY
224	Miners Ravine Confluence
225	Auburn Folsom Road
226	South Lake Circle
	SECRET RAVINE
227	Miners Ravine Confluence
228	East Roseville Parkway
229	Sucker Ravine Confluence
230	Aguilar Road Tributary Confluence
231	Rocklin Road
232	Sierra College Boulevard
233	Private Road
234	Private Road
235	Brace Road
236	Horseshoe Bar Road
237	Loomis Tributary Confluence
238	King Road Tributary Confluence
239	King Road
241	Penryn Road
242	Harris/Boulder Creek Road
243	Penryn Tributary Confluence
244	Boulder Creek Road
245	Brennans Road
246	Rock Springs Road
247	Meadow Lane
248	Los Puentes Road
249	Newcastle Road
250	Powerhouse Road
	SECRET RAVINE/SUCKER RAVINE
251	Secret Ravine Confluence
252	China Garden Road
253	Interstate 80
254	Oakridge Street
255	Lakeside Drive
256	Rocklin Road

TABLE 1-2 (CONTINUED)
LIST OF STREAM CROSSINGS AND MAJOR POINTS OF INTEREST

Number	Name
257	Quarry Lake
258	Super Span
259	Sierra Meadows Drive
260	Dominguez Road
261	Loomis Tributary Confluence
263	Pacific Street
264	Bankhead Road
265	Sierra College Boulevard
266	Saunders Avenue
267	King Road
	SUCKER RAVINE/LOOMIS TRIBUTARY
268	Sucker Ravine Confluence
270	Sierra College Boulevard
	SECRET RAVINE/AGUILAR ROAD TRIBUTARY
271	Secret Ravine Confluence
272	Aguilar Road
273	Foothill Road
274	El Don Road
275	El Don Detention Pond
276	Sierra College Boulevard
	SECRET RAVINE/LOOMIS TRIBUTARY
277	Secret Ravine Confluence
278	Interstate 80
279	Laird Street
280	King Road
	SECRET RAVINE/KING ROAD TRIBUTARY
281	Secret Ravine Confluence
282	Rancho Verde Road
283	Val Verde Road
284	King Road
	SECRET RAVINE/PENRYN TRIBUTARY
285	Secret Ravine Confluence
286	Rock Springs Road
287	East/West Forks Confluence

TABLE 1-2 (CONTINUED)
LIST OF STREAM CROSSINGS AND MAJOR POINTS OF INTEREST

Number	Name
	SECRET RAVINE/EAST FORK PENRYN TRIBUTARY
288	West Fork Confluence
289	Fairview Lane
290	Gilardi Road
	SECRET RAVINE/WEST FORK PENRYN TRIBUTARY
291	East Fork Confluence
292	Interstate 80
293	Gilardi Road



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PLACER COUNTY FLOOD CONTROL
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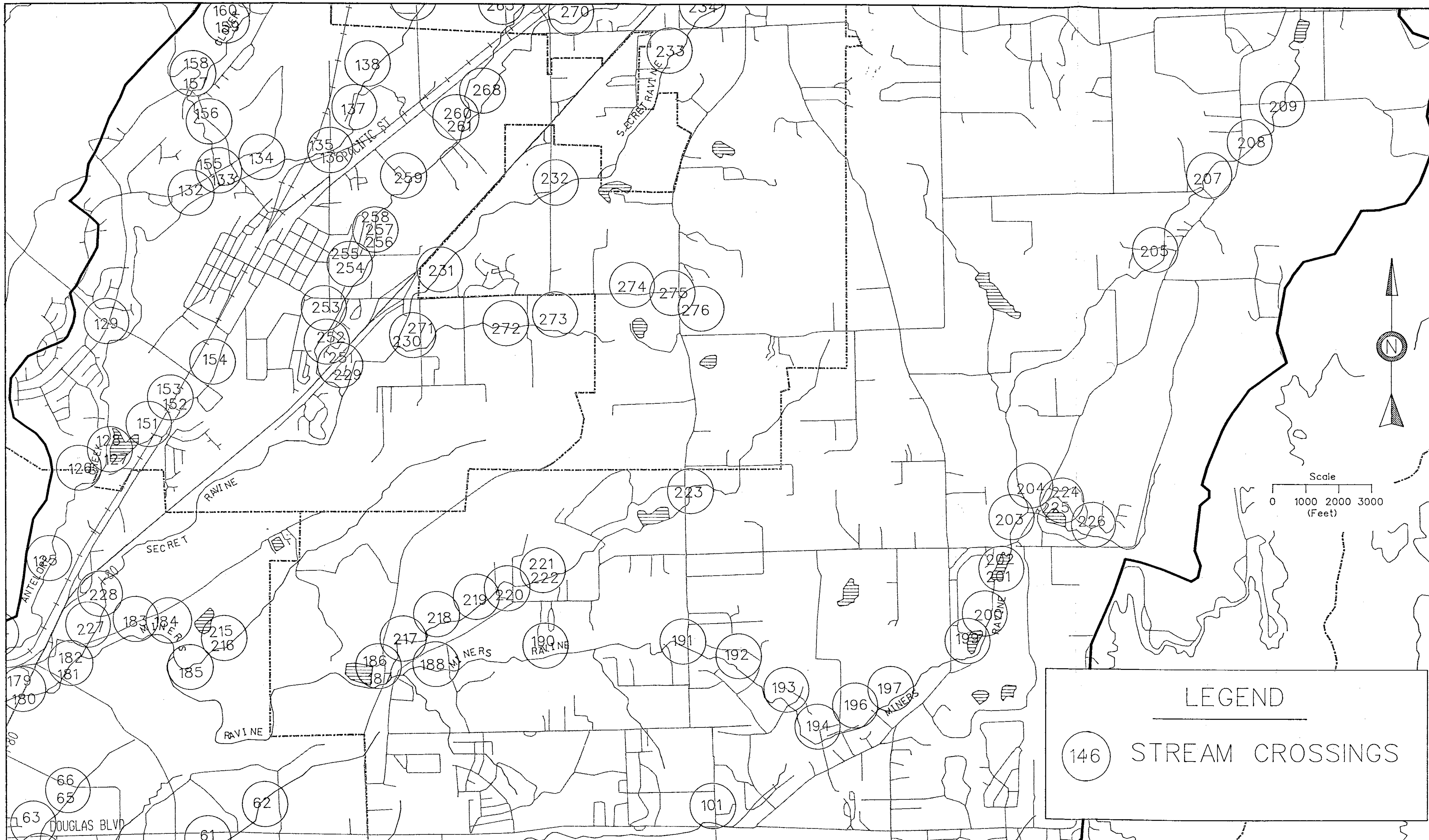
DRY CREEK WATERSHED
STREAM CROSSINGS
MAP A

FIGURE 1-7A



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PLACER COUNTY FLOOD CONTROL
AND
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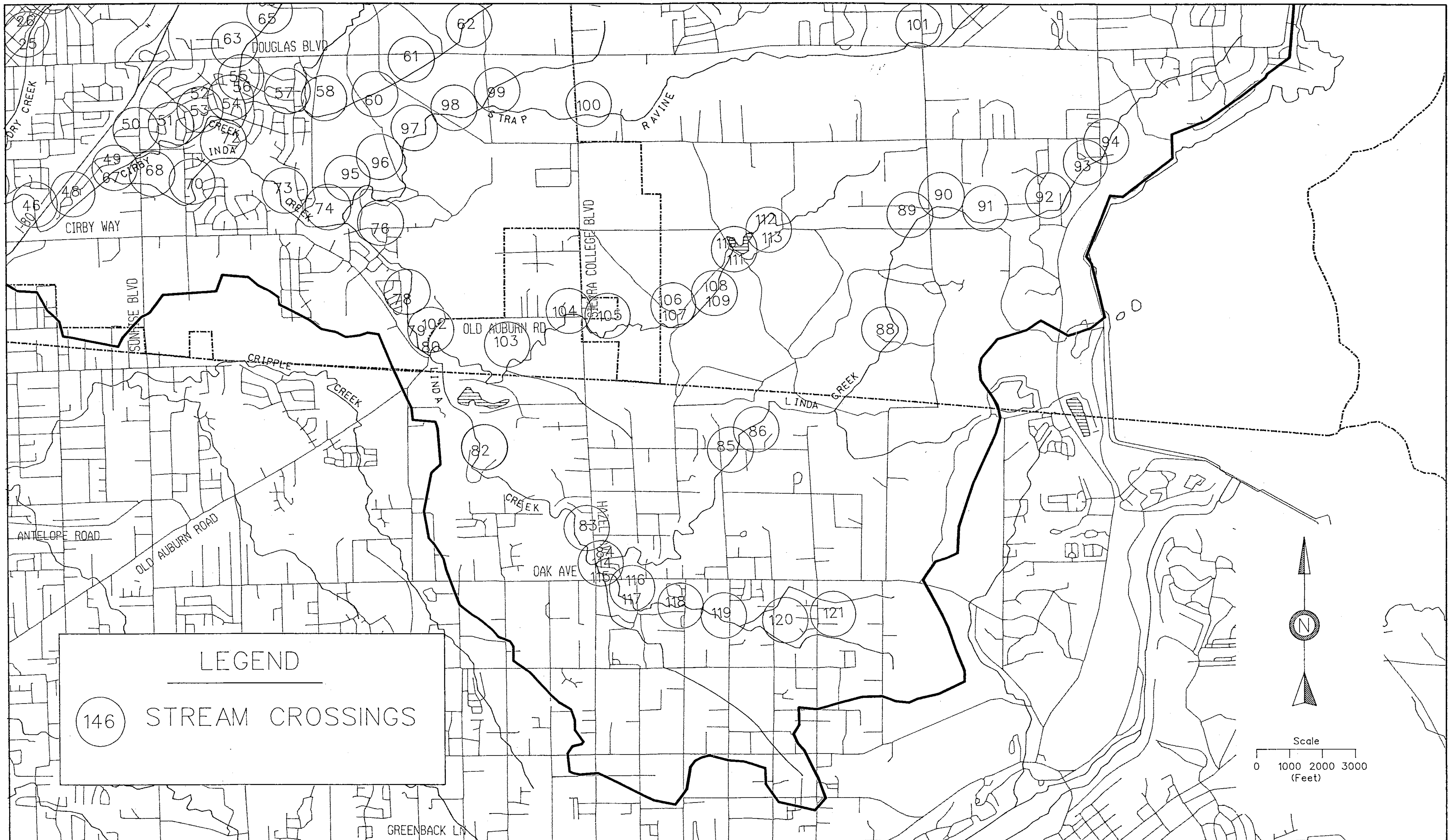
DRY CREEK WATERSHED
STREAM CROSSINGS
MAP B

FIGURE 1-7B



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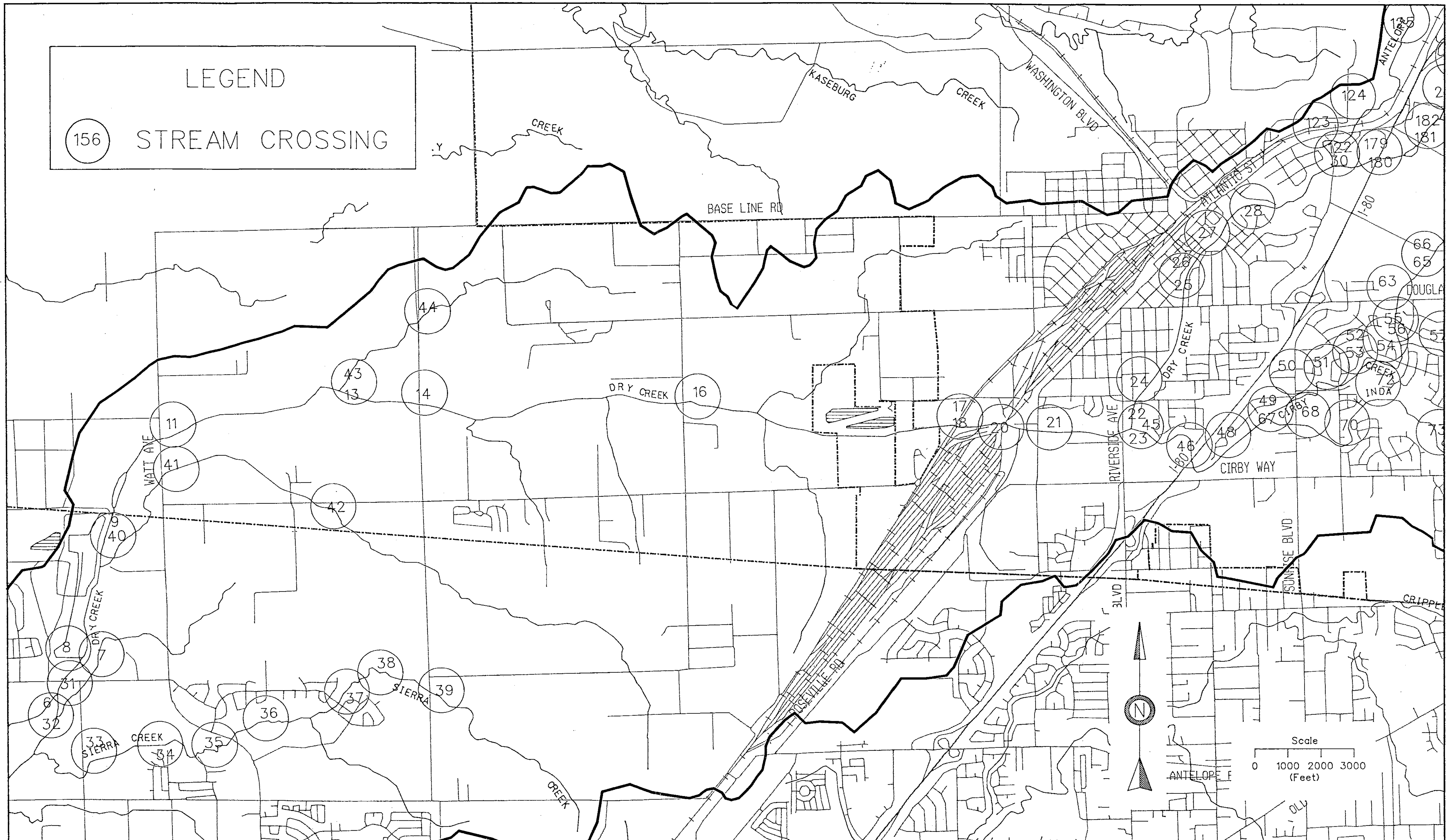
PLACER COUNTY FLOOD CONTROL
AND
WATER CONSERVATION DISTRICT

DRY CREEK WATERSHED
STREAM CROSSINGS
MAP C

FIGURE 1-7C



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PLACER COUNTY FLOOD CONTROL
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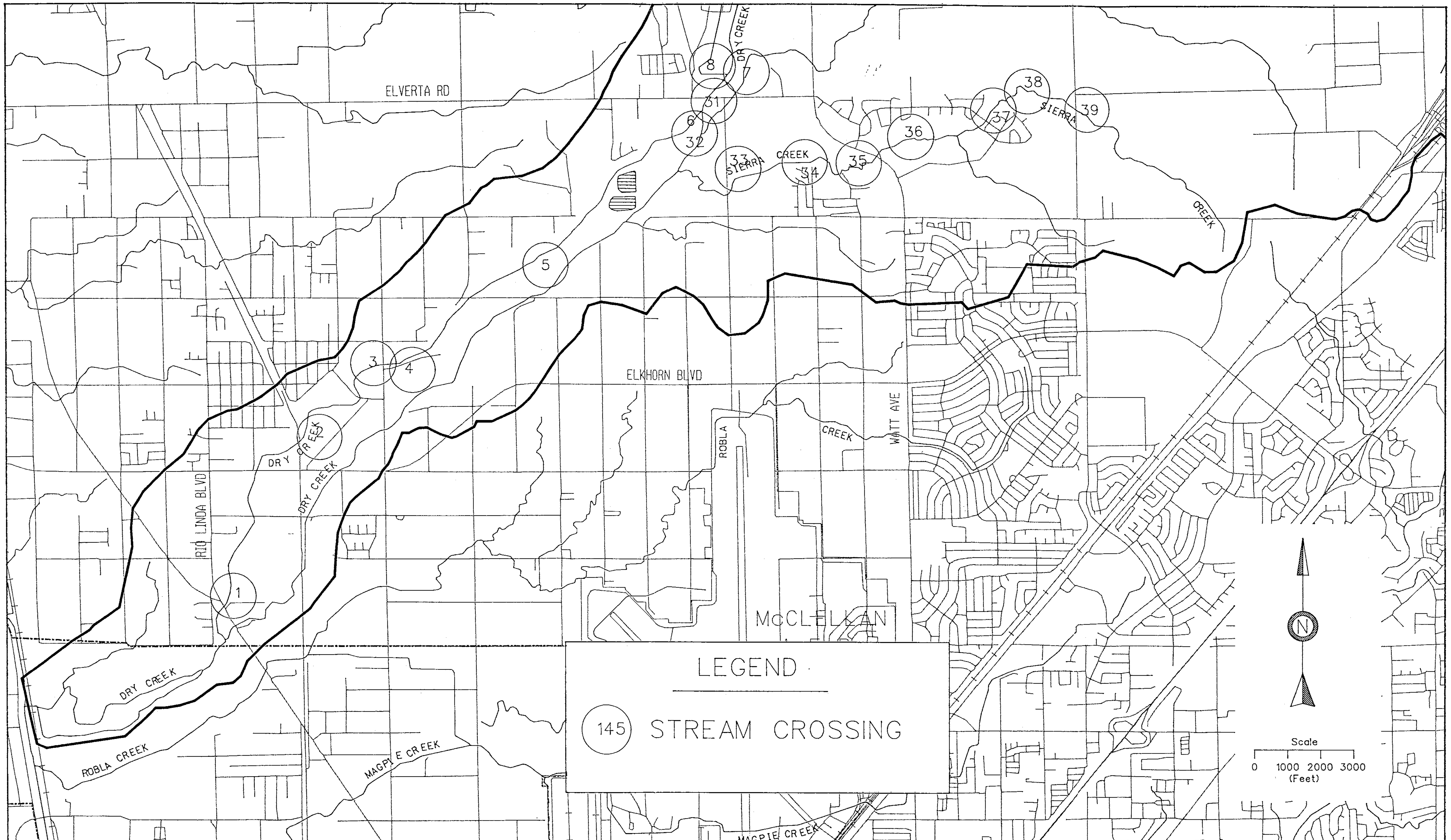
DRY CREEK WATERSHED
STREAM CROSSINGS
MAP D

FIGURE 1-7D



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PLACER COUNTY FLOOD CONTROL
AND
WATER CONSERVATION DISTRICT

DRY CREEK WATERSHED
STREAM CROSSINGS
MAP E

FIGURE 1-7E

RELATIONSHIP TO ONGOING FLOOD CONTROL PLANS

There are several flood control projects in the Dry Creek watershed that are currently either under study or are in the design phase. Each of these projects is discussed below.

SAFCA - Rio Linda

The Sacramento Area Flood Control Agency (SAFCA) is currently developing a flood control improvement plan for Dry Creek between the Placer-Sacramento County line and the mouth of Dry Creek where it enters the Natomas East Main Drainage Canal. Proposed improvements include channel improvements, bridge replacement, and levees. These improvements are being designed to provide protection for 200-year flooding events. SAFCA has been given the Dry Creek discharges, developed as part of this study, for use in their design calculations.

Roseville - Channel Improvements

The City of Roseville is currently analyzing and designing channel improvements on Linda Creek as it passes through the City. This project was previously studied by the Sacramento District, U.S. Army Corps of Engineers, but has now been passed on to the City because of a withdrawal of Federal funds for the project. The design of the channel improvements will be based on the flows developed as a part of the hydrology for the Dry Creek Watershed Flood Control Plan (this study).

Rocklin - Redevelopment

The Rocklin Redevelopment Project consists of redevelopment of central Rocklin. As part of this project, drainage from central Rocklin is being diverted to a point in Antelope Creek upstream of the current discharge location. Also included in the redevelopment project is a replacement of the Sunset Boulevard bridge over Antelope Creek, thereby reducing damages to local homes in and around Paragon Court.

Loomis - Improvements Program

The Loomis Improvements Program resulted in an inventory of stream crossings in Loomis that needed to be replaced, either because of increased traffic or because of inadequate flow capacity. These stream crossings either have been or are in the process of being replaced and will not be included in this plan.

FEMA - Flood Insurance Studies

The Federal Emergency Management Agency (FEMA) will be revising the Flood Insurance Studies for a number of areas in Dry Creek Watershed. The flood elevations will be based on HEC-2 model runs using the flood flows developed as a part of this study.

CHAPTER 2
HYDROLOGIC ANALYSIS

The hydrologic analysis for the Dry Creek Watershed Flood Control Plan is based on parameters and techniques specified in the Placer County Flood Control and Water Conservation District "Stormwater Management Manual." For the additional analyses that were conducted as part of this study, the methodologies used are in agreement with the intent of the manual. The purpose of the hydrologic analysis portion of this study is to determine how the watershed reacts to precipitation. This is accomplished through the use of a computer model that mathematically represents the physical processes of rainfall and the resulting runoff.

REGIONAL HYDROLOGIC ANALYSIS

A regional hydrologic analysis was performed in order to facilitate calibration of the HEC-1 hydrologic model of the Dry Creek watershed. Observed flow data was only available at one location on Dry Creek, at the City of Roseville with a drainage area of 78 square miles. A regional hydrologic analysis provided peak flow estimates versus recurrence interval for other drainage areas and tributaries.

The U.S. Geological Survey (USGS) published a regional peak flow hydrologic analysis in 1977 (Magnitude and Frequency of Floods in California, Waananen and Crippen). However, their analysis did not differentiate between high elevation Sierra Nevada streams and Sacramento Valley foothill streams. To provide more accurate estimates of peak flow recurrence statistics for Dry Creek, stream records representative of the foothills were graphically analyzed. Peak flow statistics for these streams are shown in Table 2-1.

Regression equations developed from this data and used for predicting peak flows from undeveloped drainage areas are listed at the end of Table 2-1. Peak flow estimates from these equations were used as guides in evaluating model calibration for design precipitation recurrence intervals of 2, 10, 25, 100, 200, and 500 years.

DESCRIPTION OF MODELS

A major portion of this study entailed the development and calibration of a hydrologic model of the Dry Creek watershed. This model simulates the runoff in the watershed in response to precipitation. The computer model of the watershed is a tool that is used to predict the amounts and timing of runoff from a wide variety of simulated rainfall events. As specified in the Placer County Stormwater Management Manual, HEC-1 was used to develop the hydrologic model of the watershed.

In some instances it was also advantageous to have a HEC-2 hydraulic model of some of the streams in the watershed. The hydraulic model aided in the determination of the water surface elevations associated with various streamflows.

HEC-1 Model

The HEC-1 model is designed to simulate the surface runoff response of a watershed to precipitation. This is accomplished by representing the watershed as an interconnected system of hydrologic and hydraulic components. Each model component represents a

TABLE 2-1

REGIONAL PEAK FLOW STATISTICAL ANALYSIS

Streamgage	Area (sq mi)	Years Record	2-year	10-year	25-year	100-year	500-year
Dry Creek	78.2	37	1900	5800	8700	14000	22000
Arcade Creek	31.5	15	1000	2850	4300	6900	10500
Dry Creek Trib.	0.4	14	52	145	200	290	430
Oregon Creek	34.4	56	1370	3560	5050	7770	11500
Sucker Run	18.7	11	755	1820	2520	3790	5500
Bear Creek Trib.	4.5	13	214	700	1060	1710	2700

Coefficients for Regional Equation $Q = a * \text{Area}^{b}$

Return Period	a	b
2-Year	109	0.66
10-Year	272	0.69
25-Year	360	0.72
100-Year	580	0.72
200-Year	670	0.73
500-Year	850	0.74

specific aspect of the rainfall-runoff processes occurring in a portion of the watershed. A component may represent the runoff occurring in a subbasin, the routing of flows down a stream channel, or the routing of flows through a reservoir. Description of the components of a model requires estimation of a set of parameters that describes the hydrologic and hydraulic characteristics of the components. Parameters describing the various components of the model are based on land use, soils, vegetation, and topography. For example, the land use in a subbasin will determine the percentage of that subbasin that is impervious and the average condition of the drainage channels. The end result of the modeling process is the computation of streamflow hydrographs at specified locations throughout the watershed.

HEC-2 Model

The HEC-2 model is used to compute the water surface profiles of one-dimensional, steady, gradually varied flow in streams. The program uses the solves energy and energy loss equations between adjacent flow cross sections. Output from HEC-2 is in the form of steady-state water surface profiles for the modeled stream reaches. It is also possible to obtain the storage in a reach based on a given flow rate. This capability of HEC-2 was used, where possible, to develop modified Puls routing parameters for use in HEC-1 routing.

HEC-2 was used for stream reaches where detailed cross section information was available from other sources, or where surveys were done as part of this study, to determine approximate flow versus reach storage relationships as well as water surface elevations for given discharges.

HEC-1 MODEL DEVELOPMENT

This section of the report describes the assumptions and criteria that were used in developing the HEC-1 model of the Dry Creek watershed.

Model Limitations

Whenever the use of a model is considered, or when the results of a model are interpreted, it is very important to understand the limitations that apply to the use of the model. The most important of these limitations, as they relate to the model of the Dry Creek watershed, are discussed in the following paragraphs.

Nature of Results Approximate. Probably the most crucial limitation is that any model can only approximate the real world hydrologic and hydraulic processes. The HEC-1 model uses a number of simple mathematical and empirical methods to represent the complex physical processes that produce runoff from precipitation and route that runoff through a watershed. Although these methods are among the best currently available, they are still only mathematical or empirical simplifications of complex physical processes.

Further, a number of simplifying assumptions must be used to describe the watershed in the model. The assumptions and criteria used in developing the Dry Creek watershed HEC-1 model are described in a following section.

Consistency a Goal. One of the important goals of the modeling effort for the Dry Creek watershed was to set up the model using standard, accepted, consistent, and logical rules that could be applied to all areas in the watershed with consistent and reliable results. This took the form of a spreadsheet database containing all of the parameters describing each subbasin and routing reach. The parameters were combined with formulas in the spreadsheet to develop the input data needed for the HEC-1 model. For example, subbasin 'n' values, lengths, and slopes are combined in the spreadsheet to produce T_p, the basin lag time for the Snyder unit hydrograph method. Subbasin infiltration coefficients and percent impervious are obtained in a similar manner.

Level of Detail. By its very nature, a model does not give a complete and detailed representation of any of the subbasins or of the watershed as a whole. Drainage subbasins used in the HEC-1 computer model of the Dry Creek watershed all cover more than 200 acres as a minimum, with the average size of a subbasin being 600 acres or slightly less than one square mile. Using subbasins of this size requires simplifying the representation of the subbasin. All of the methods used to simplify the subbasin representation revolve around that basic assumption that the subbasin is homogeneous, or if it is not, that the subbasin parameters can be averaged to model the subbasin as if it were homogeneous;

Because of the large number of subbasins involved, it is not possible to assure that every subbasin is represented in the highest level of detail. There may be features in any water shed that, upon more detailed investigation, may be found to affect streamflows. However, on the average, it is expected that the streamflows obtained from the model will be accurate for the watershed as a whole.

It was necessary to obtain peak flow results at many locations that were not represented explicitly in the model. Peak flow estimates from locations specified in the model were used to interpolate peak flows at other locations of interest, such as areas where historic flooding has occurred or a location where a stream crosses a road. This interpolation had to take into account not only the peak flow produced by a particular subbasin or group of subbasins, but also the routing of the flow to the location in question and the timing of the peaks of the subbasin runoff and the routed runoff. Interpolation tables, containing the interpolation criteria for each point of interest in the watershed, were developed and are contained in the Appendix. These tables were used to combine the output from various model runs to predict flows at all locations of interest in the Dry Creek watershed.

Assumptions and Criteria

This section of the report will detail the assumptions and criteria that were used in developing and calibrating the HEC-1 model of the Dry Creek watershed. Many of the assumptions were made in order to provide consistency and ease of use of the model as described above.

Unit Hydrograph Parameters. As suggested in the Stormwater Management Manual, the Snyder unit hydrograph method was chosen to represent the rainfall/runoff process occurring in each basin. This method requires two input parameters, standard lag (T_p) in hours and a peaking coefficient (C_p). Standard lag, or lag time, is described as the time that the rise in runoff lags the rainfall causing the rise.

The equation used to compute the T_p was taken from the USBR's "Flood Hydrology Manual" (1989) and is given below.

$$T_p = 26 * n\left(\frac{LL_c}{S^{0.5}}\right)^{0.33}$$

where T_p = lag time in hours
L = length of the longest watercourse in the subbasin, in miles
L_c = length along the longest watercourse from the point of concentration to a point opposite the centroid of the subbasin, in miles
S = overall slope of the channel in ft/mile
n = a physical parameter related to the hydraulic roughness characteristics of the watershed

Loss Rates. Loss rates represent the infiltration of rainfall into the ground. The initial and uniform loss rate option in HEC-1 was used to describe the loss rates in the Dry Creek watershed. In order to account for the variability of the soil and land use characteristics, a weighted infiltration coefficient was developed for each subbasin. Table 5-4 in the Placer County Stormwater Management Manual defines soil loss rates for each soil group and vegetative cover. For the purposes of estimating soil loss rates for this study, the vegetative cover in developed areas was assumed to be urban landscaping, and the cover in undeveloped areas was assumed to be annual grasses. The weighting formula for determining subbasin loss rate is given below.

$$\frac{1}{A}\sum_{i=1\rightarrow A}\left[(A_i)_{dev} * (L_i)_{ls} + (A_i)_{und} * (L_i)_{ag}\right]$$

where A_i = Area in i-type soil group within the subbasin
L_i = Loss rate in inches/hr for i-type soil group
dev = developed areas
und = undeveloped areas
ls = landscaped cover
ag = annual grass cover

The constant loss rate for each subbasin was not changed for each of the design storm events under study because it represents the loss rate of saturated soil. The initial losses were changed for each of the design storms as shown below:

Design Storm Return Period	Initial Loss (inches)
2-year	.41
10-year	.38
25-year	.10
100-year	.10

Initial losses for the 100-year design storm were determined from the model calibration to the February 1986 flood event. Initial losses for the 2-year were estimated based on the calibration of the model to a storm event occurring in March 1989. Initial losses for the 25- and 10-year storms were based on a correlation between the calibrated values for the 100- and 2-year storms and regional regression equations describing the relationship between rainfall and runoff.

Initial Conditions. Initial conditions describe the streamflows at the beginning of the storm that is being modeled. If the storm is a historical one, initial conditions can be determined from streamgage records, if they are available. HEC-1 uses the Base Flow (BF) variable to quantify the streamflow at the beginning of the simulation. This parameter is intended to describe the flows that can be attributed to groundwater recession flows. The definition attributed to the BF variable in HEC-1 was changed for the Dry Creek watershed model to describe the streamflow at the beginning of the simulation, independent of the source. This change in definition allows the model to represent antecedent conditions in the watershed that can't be adequately described any other way.

The BF variable was used in the model to represent the antecedent conditions of streamflow that can be a major factor causing flooding in the watershed. The values of the BF variable, in cfs flow per square mile, area shown below

Design Storm Return Period	BF Initial Conditions (cfs/sq.mi.)
2-year	2.5
10-year	7
25-year	11
100-year	23

Precipitation. Design storm precipitation for the HEC-1 model of the Dry Creek watershed was derived from tables given in the Placer County Stormwater Management Manual. Depth-Duration-Frequency data was used to construct synthetic design storms of 6-hour duration for cloudburst events and 24-hour duration for general rainstorms. Precipitation was adjusted for average basin elevation for each duration. Cloudburst storm centerings resulted in additional adjustments to the 1-hour maximum intensity values depending on the location of the storm template isohyets. Five-minute timesteps were used for the 6-hour cloudburst events, and 1-hour timesteps were used for the general rain storms. For a watershed the size of Dry Creek, it was determined that cloudburst events produced higher runoff than did the general storm for all recurrence intervals greater than two years. Figure 2-1 is a map of the Dry Creek watershed with the 100-year cloudburst template superimposed.

100-Year Storm Centerings. The use of cloudburst storm data requires that the cloudburst be centered over different locations in the watershed depending on the point at which the peak flow is wanted. For the 100-year recurrence interval event, seventy-four different storm centerings, in addition to centering the cloudburst storm over each individual subbasin, were required to provide peak flows at all locations in the watershed where flows were generated or combined. It was determined through test model runs that the storm centering producing the highest flows in Dry Creek at Vernon Street also produced the highest flows for Dry Creek at all locations downstream of Vernon Street. Therefore, additional storm centerings for areas downstream of Vernon Street were only performed for tributaries to Dry Creek and not for Dry Creek itself.

25- and 10-Year Storm Centerings. The storm size for the 25- and 10-year storm event is smaller in areal coverage than the 100-year event and would require even more storm centerings than were required for the 100-year event. This large number of required storm centerings precluded using the same technique for these events that was used for the 100-year event. Instead, storm centerings for four to five locations in each major tributary (Miners Ravine, Secret Ravine, Antelope Creek, and Linda Creek), with different drainage areas were developed. The peak flows and contributing areas for these locations were used to develop a regression equation for each tributary that related peak flow to subbasin area. The form of the regression equations relating area and peak flows is:

$$Q = \alpha A^{\beta}$$

Where: Q = Peak flow from the subbasin;
A = Area of subbasin; and
α, β = Coefficients

Representative graphs of the relationships are illustrated in Figure 2-2, and values of the coefficients for each of the major tributaries and both the 1989 and Future development conditions are listed in Table 2-2.

TABLE 2-2

25- AND 10-YEAR REGRESSION EQUATION COEFFICIENTS

Major Tributary	Development Condition							
	1989				Buildout			
	25-Year		10-Year		25-Year		10-Year	
	α	β	α	β	α	β	α	β
Miners Ravine	461.20	0.60	362.11	0.53	631.95	0.54	450.62	0.49
Secret Ravine	360.87	0.67	249.96	0.66	672.97	0.49	517.94	0.44
Antelope Creek	322.93	0.78	236.26	0.73	531.03	0.61	414.42	0.54
Linda Creek	336.21	0.80	254.29	0.75	383.04	0.77	288.27	0.75

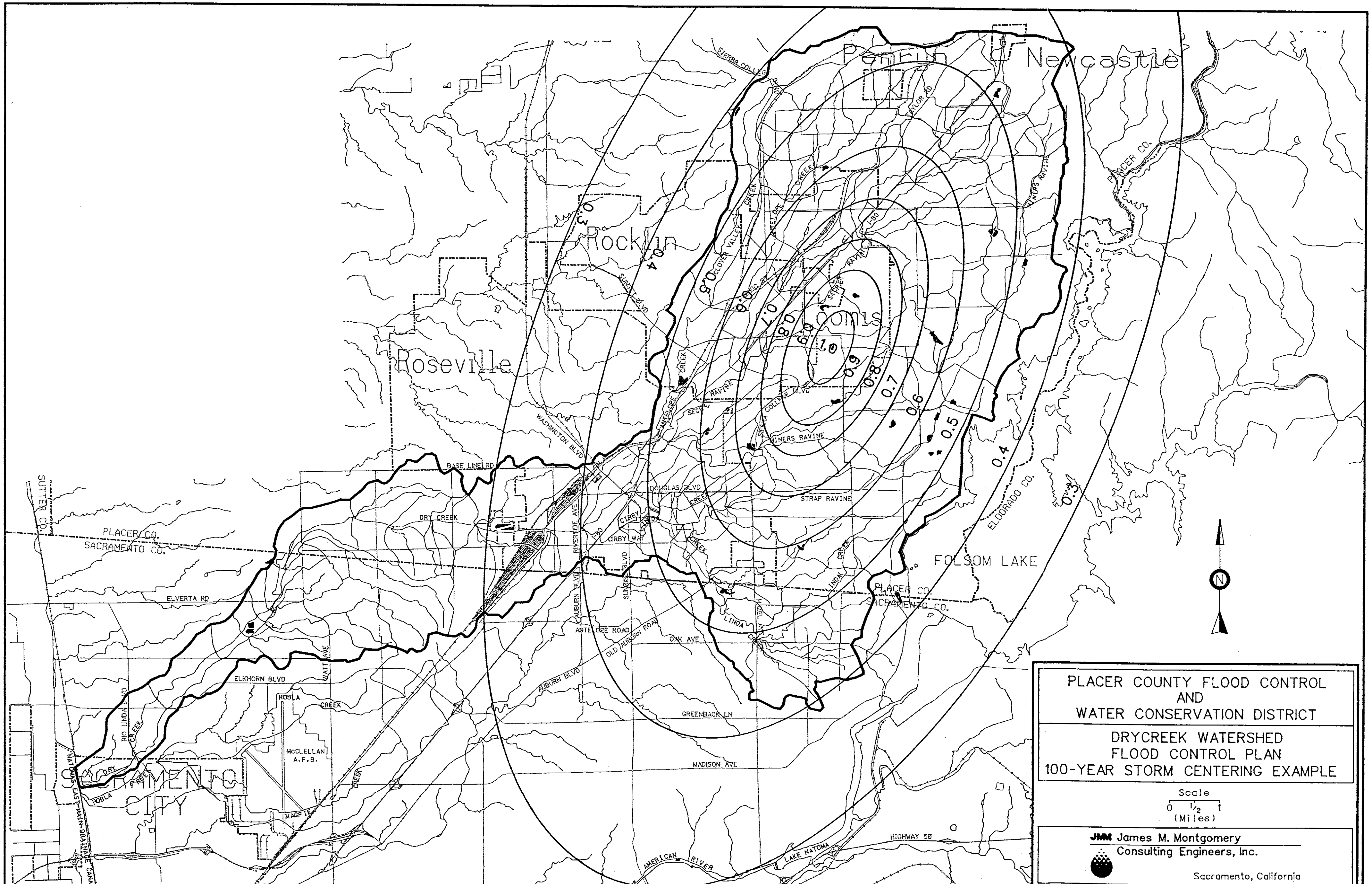
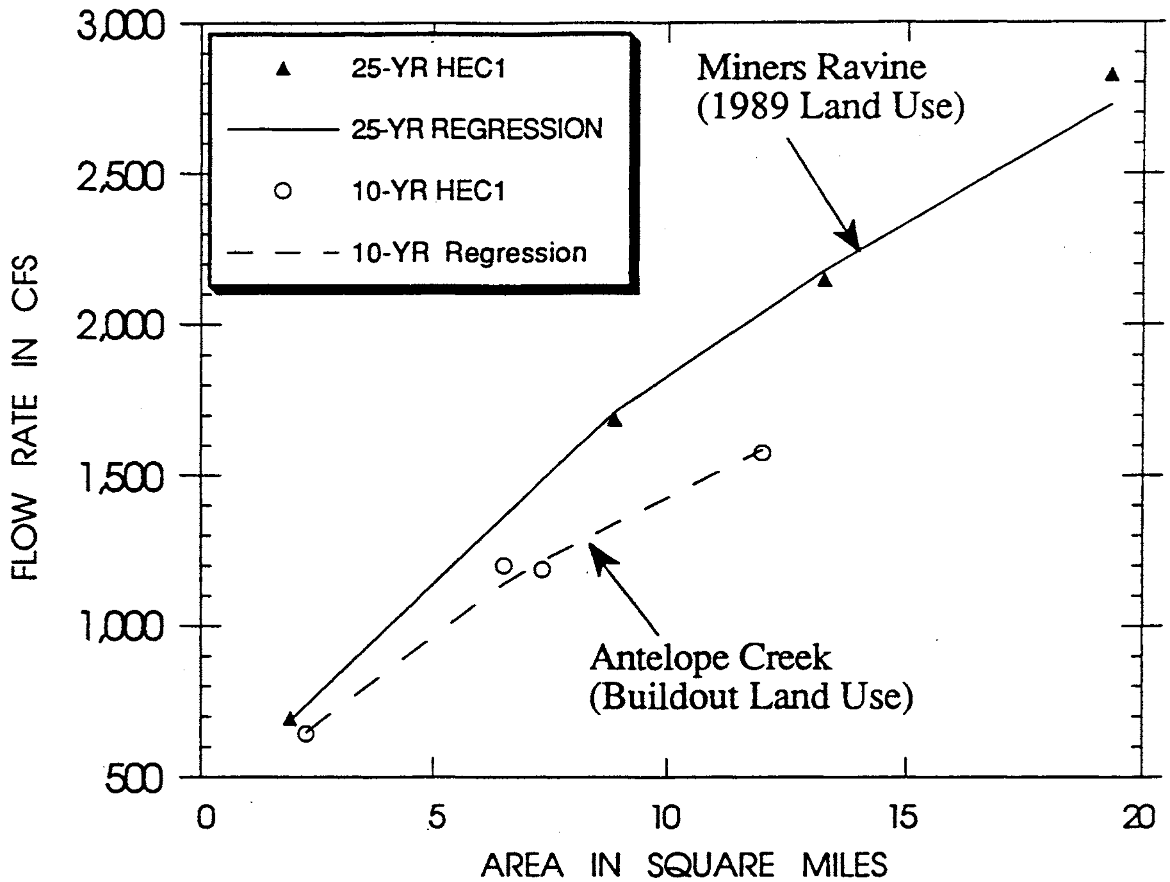

PLACER COUNTY FLOOD CONTROL
AND
WATER CONSERVATION DISTRICT
DRYCREEK WATERSHED
FLOOD CONTROL PLAN
100-YEAR STORM CENTERING EXAMPLE
Scale
0 1/2 1
(Miles)
JMM James M. Montgomery
Consulting Engineers, Inc.
Sacramento, California
Penryn
Newcastle
Rocklin
Loomis
Roseville
SACRAMENTO CITY
FOLSOM LAKE
PLACER CO.
SACRAMENTO CO.
ELDORADO CO.
SUTTER CO.
McCLELLAN A.F.B.
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3

FIGURE 2-1



25- AND 10-YEAR REGRESSION PLOTS
FIGURE 2-2

In addition to the regression runs described above, storm center model runs were used to determine the discharges for all the subbasins of Cirby Creek and Strap Ravine, and all of the HEC-1 combination points downstream of the mouths of the four major tributaries. Storm center model runs were also made for subbasins that were determined to have hydrologic parameters that were substantially different from the majority of the subbasins on a major tributary.

2-Year Storm. The 2-year recurrence design storm involved the use of two different types of storms. Runoff for each individual subbasin was determined using storm centering techniques and a 2-year recurrence cloudburst storm. Runoff for the remainder of the concentration points in the watershed was determined using a 2-year general storm. A general storm is described one having the same intensity over the entire watershed at any given time.

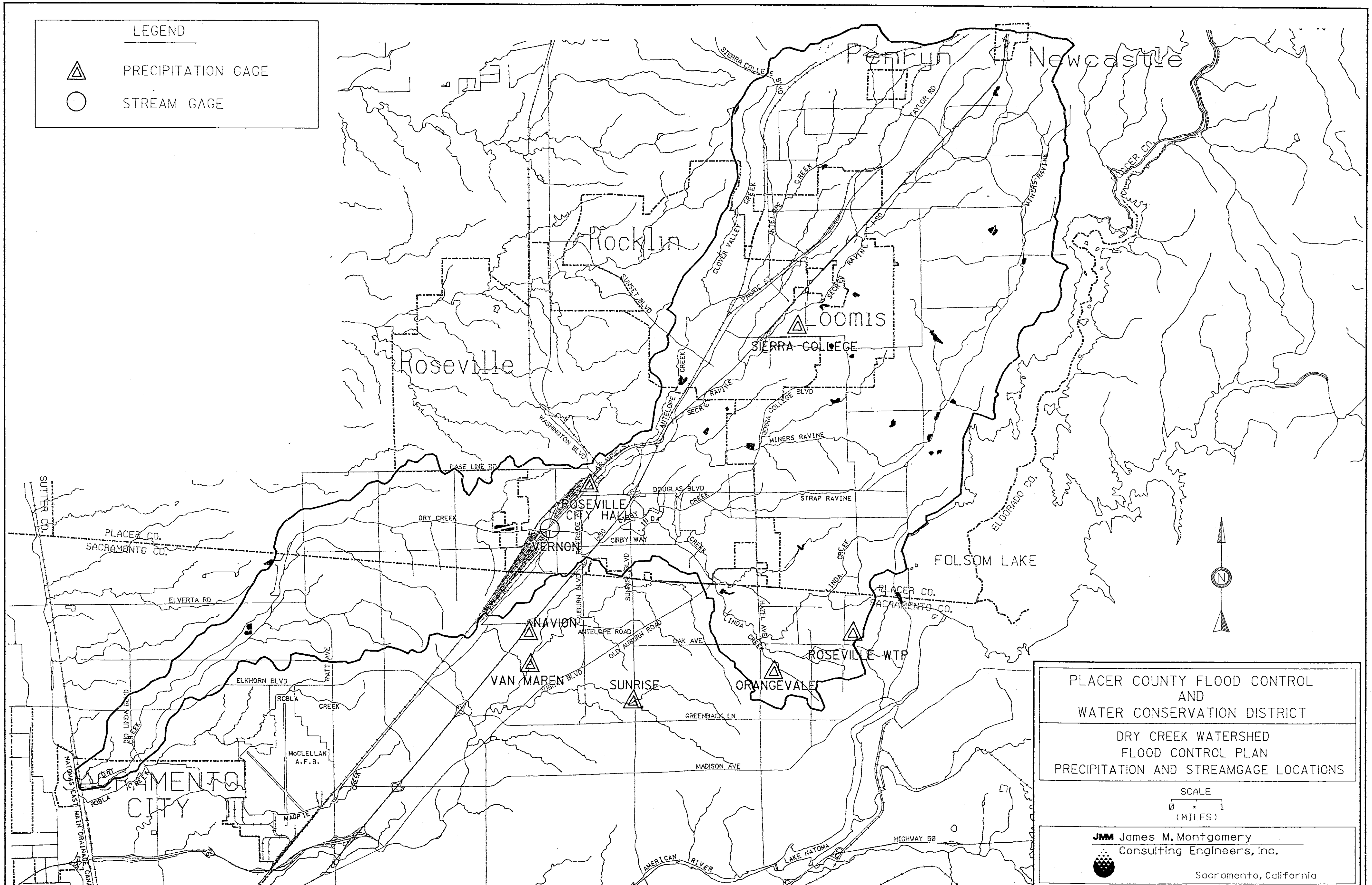
Calibration Precipitation. The precipitation used for calibration of the HEC-1 model was based on actual rain gage data collected during the calibration events. The locations of precipitation stations used for calibration of the Dry Creek watershed HEC-1 model are shown on Figure 2-3. Assignment of gage data to individual subbasins for calibration runs was based on Thiessen polygons and storm track data.

Routing. Most of Dry Creek and its tributaries have been included in flood studies by the Federal Emergency Management Agency (FEMA) or the U.S. Army Corps of Engineers (COE). Flood studies have included Dry Creek from the Natomas East Main Drainage Canal through Roseville; Antelope Creek upstream through Loomis; Secret Ravine through Loomis; Clover Valley Creek to Sierra College Blvd; Miners Ravine to its headwaters; and Linda and Cirby Creeks in the Roseville city limits. The HEC-2 backwater computer program set up in these areas allowed the use of more accurate Modified Puls storage routing in reaches covered by these studies. The Modified Puls routing takes into account the in-channel and overbank storage available in a reach.

Detailed data for use in the Modified Puls routing method, were not available in the remaining stream reaches, including upper Linda Creek and the headwater sections of Secret Ravine and Antelope Creek. In these reaches the Muskingum routing method was used. Reach travel times are estimated using an assumed normal depth velocity based on the estimated friction coefficients. The selection of the hydrograph peaking (X) coefficients for Muskingum routing was based on work done by the USBR and the US Army COE.

Subbasin Descriptions

The entire Dry creek watershed area was subdivided into 129 subbasins to provide the necessary detail for the purpose of this study. This subdivision is made on the basis of hydrologic characteristics of the watershed with the goal of providing HEC-1 model output at stream junctions, major bridges and crossings, problem areas, and downstream boundaries. Subbasin hydrologic divisions were based on topography from the USGS 1:24,000 scale topographic maps. The subbasin areas range from about two square miles (1280 acres) to around 0.3 square miles (200 acres). Figure 2-4 shows all the study subbasins in the Dry Creek watershed. Table 2-3 presents most of the pertinent data and parameters for each subbasin in the watershed for the February 1986 calibration event. The method of obtaining the data and parameters is described below.



LEGEND
PRECIPITATION GAGE
STREAM GAGE
Penryn
Newcastle
Rocklin
Loomis
SIERRA COLLEGE
Roseville
ROSEVILLE CITY HALL
VERNON
NAVION
VAN MAREN
SUNRISE
ORANGEVALE
ROSEVILLE WTP
FOLSOM LAKE
PLACER CO.
SACRAMENTO CO.
SUTTER CO.
ELDORADO CO.
DRY CREEK
BASE LINE RD
ELVERTA RD
ELKHORN BLVD
GREENBACK LN
MADISON AVE
HIGHWAY 50
AMERICAN RIVER
LAKE NATOMA
McCLELLAN A.F.B.
SACRAMENTO CITY
NATOMAS EAST MAIN DRAINAGE CANAL
ANTELOPE ROAD
OLD AUBURN ROAD
OAK AVE
DOUGLAS BLVD
STRAP RAVINE
MINERS RAVINE
SECRET RAVINE
SIERRA COLLEGE BLVD
CLOVER VALLEY CREEK
ANTELOPE CREEK
LINDA CREEK
CIRBY WAY
SUNSET BLVD
WASHINGTON BLVD
TAYLOR RD
PLACER COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT
DRY CREEK WATERSHED FLOOD CONTROL PLAN PRECIPITATION AND STREAMGAGE LOCATIONS
SCALE
0 1
(MILES)
JMM James M. Montgomery Consulting Engineers, Inc.
Sacramento, California

FIGURE 2-3

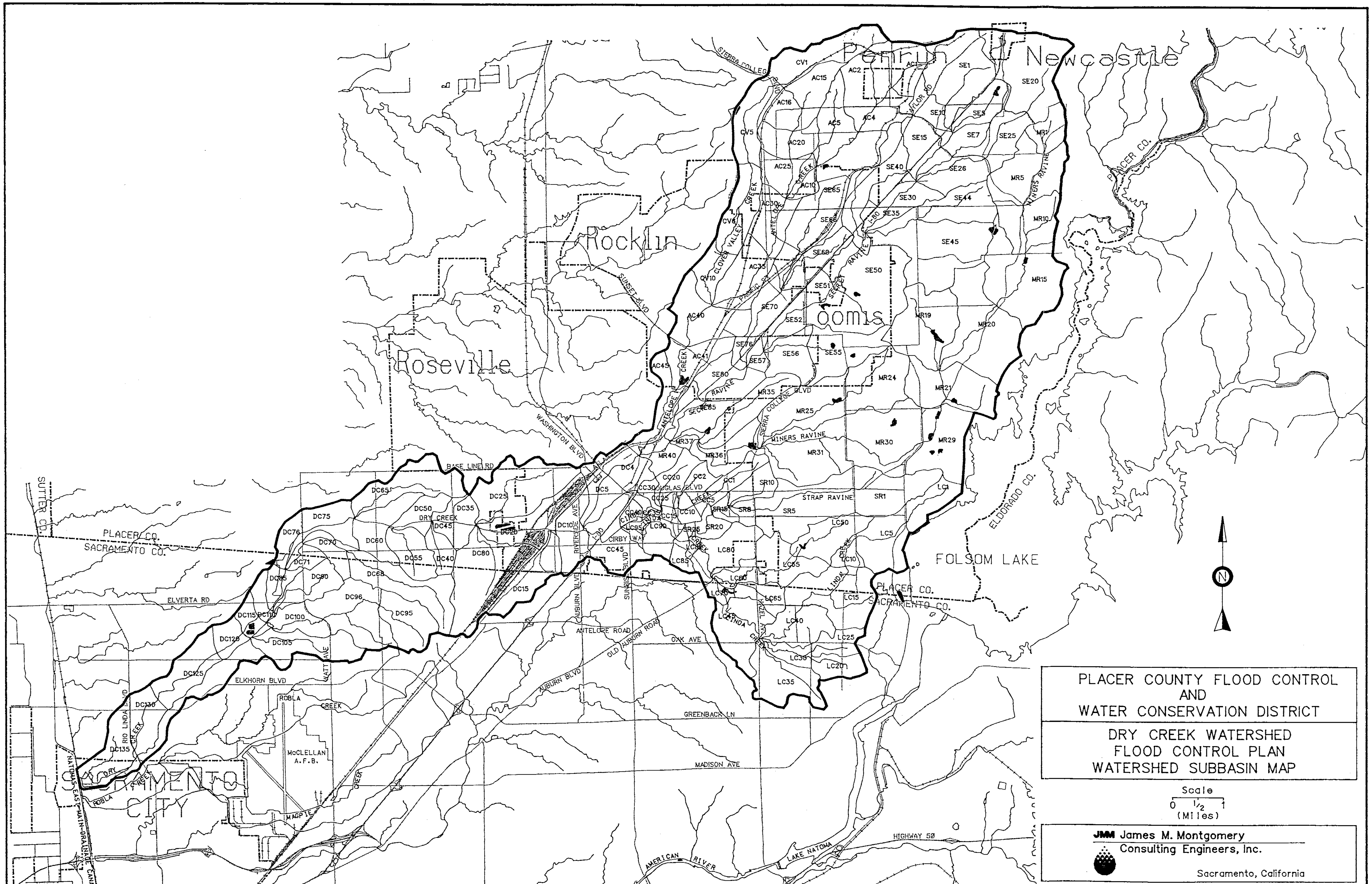

PLACER COUNTY FLOOD CONTROL
AND
WATER CONSERVATION DISTRICT
DRY CREEK WATERSHED
FLOOD CONTROL PLAN
WATERSHED SUBBASIN MAP
Scale
0 1/2 1
(Miles)
JMM James M. Montgomery
Consulting Engineers, Inc.
Sacramento, California
Penryn
Newcastle
Rocklin
Loomis
Roseville
Sacramento City
FOLSOM LAKE
PLACER CO.
SACRAMENTO CO.
SUTTER CO.
ELDORADO CO.
McCLELLAN A.F.B.
AMERICAN RIVER
LAKE NATOMA
HIGHWAY 50
BASE LINE RD
ELVERTA RD
ELKHORN BLVD
ANTELOPE ROAD
OLD AUBURN ROAD
OAK AVE
AUBURN BLVD
GREENBACK LN
MADISON AVE
WASHINGTON BLVD
SUNSET BLVD
SIERRA COLLEGE BLVD
STRAP RAVINE
MINERS RAVINE
DRY CREEK
N

FIGURE 2-4

TABLE 2-3

1986 CALIBRATION SUBBASIN HYDROLOGIC DATA

Basin ID	Basin Description	Basin Area (sq mi)	Chan DElev (ft)	Basin UElev (ft)	Basin Length (mi)	Basin Centrd (mi)	Basin Slope (ft/mi)	Basin Type (Tab2-4)	Basin 'n'	Basin Ct	Basin Lag (hr)	Basin Cp	Imp Area (%)	1986 Land Use Conditions (%): Comm 0.90	HDR 0.60	MDR 0.30	LDR 0.20	RLDR 0.15	RR/RE 0.10	Open 0.02	Loss Rates (in/hr)	Soil Classification: A:.48 A:.31	B:.25 B:.16	C:.16 C:.09	D:.12 D:.07
LC1	Auburn-Folsom Road	0.57	380	460	1.14	0.64	70.4	4	0.063	1.64	0.73	0.60	25	5		40	10	40		5	0.12			75	25
LC5	Barton Road	0.95	320	380	1.10	0.53	54.6	4	0.075	1.96	0.85	0.60	15	2	2			76		20	0.09			65	35
LC10	Wedgewood Drive	0.25	300	320	0.64	0.19	31.1	3	0.101	2.62	0.74	0.60	3					5		95	0.07			15	85
LC15	Cherry Avenue	1.55	230	300	1.36	0.76	51.3	3	0.085	2.20	1.16	0.60	5					20		80	0.11		40		60
LC20	Walnut Avenue	0.45	220	260	0.76	0.57	52.8	3	0.057	1.47	0.58	0.60	17			10		90			0.13		55		45
LC25	Walnut Avenue	0.41	220	330	0.91	0.76	121.0	3	0.057	1.47	0.59	0.60	17			10		90			0.08		10		90
LC30	Oak Avenue	0.32	195	220	1.17	0.76	21.3	3	0.064	1.67	0.97	0.60	11					70		30	0.13		70		30
LC35	Oak Avenue	1.12	210	251	1.29	0.49	31.8	3	0.056	1.45	0.70	0.60	17			15		85			0.11		35		65
LC40	Hazel Avenue	0.87	195	230	1.48	1.14	23.7	3	0.062	1.61	1.13	0.60	12					80		20	0.12		50		50
LC45	Indian Creek Drive	1.18	170	220	1.44	0.49	34.7	3	0.060	1.56	0.77	0.60	14			5		80		15	0.08		5		95
LC50	Treelake Road	0.84	240	345	1.29	0.85	81.5	3	0.081	2.12	1.06	0.60	5						40	60	0.08			35	65
LC55	Sierra College Blvd	0.89	197	240	0.98	0.61	43.7	3	0.110	2.86	1.29	0.60	2							100	0.08		15	5	80
LC60	Linda Creek	0.30	168	197	1.17	0.68	24.7	3	0.073	1.91	1.05	0.60	7					40		60	0.09		20		80
LC65	Country Lake Drive	0.43	180	220	0.72	0.53	55.6	3	0.058	1.50	0.56	0.60	15	0	0	3	0	97		0	0.11	0	45	0	55
LC70	Old Auburn Road	0.18	168	170	0.59	0.30	3.4	3	0.058	1.52	0.70	0.60	15					100			0.07	0	0	0	100
LC80	Champion Oaks Drive	0.98	149	230	1.29	0.19	62.9	3	0.053	1.38	0.44	0.60	20			60		10		30	0.12		15		85
LC82	Strap Ravine	0.09	141	149	0.27	0.15	30.2	3	0.048	1.24	0.25	0.60	28		40	10				50	0.12		25		75
LC85	Rocky Ridge Drive	0.26	140	141	0.57	0.08	1.8	3	0.045	1.18	0.38	0.60	34	0	35	40				25	0.13		20		80
LC90	Oak Ridge Drive	0.46	133	140	0.95	0.57	7.4	3	0.044	1.14	0.67	0.60	37	0	50	20	0	0		30	0.14		30		70
LC95	Cirby Creek	0.16	130	133	0.42	0.23	7.2	3	0.036	0.94	0.31	0.75	69	50	40					10	0.17		40		60
CC1	Douglas Boulevard	0.38	230	260	0.87	0.38	34.4	3	0.094	2.44	0.94	0.60	3	0	0	0	0	10	0	90	0.07	0	0	5	95
CC2	Douglas Boulevard	0.25	195	220	0.49	0.38	50.8	3	0.110	2.86	0.86	0.60	2	0					0	100	0.07				100
CC5	East Roseville Parkway	0.20	195	270	0.27	0.27	282.9	2	0.039	1.02	0.17	0.60	20	20						80	0.09		15		85
CC10	Huntington Drive	0.24	151	190	0.42	0.08	93.6	2	0.043	1.12	0.17	0.60	15			45				55	0.13		35		65
CC15	Sierra Gardens Drive	0.15	150	151	0.21	0.09	4.8	2	0.028	0.73	0.15	0.69	57	10	80					10	0.13		15		85
CC20	Douglas Boulevard	0.38	151	230	0.95	0.25	83.4	3	0.076	1.98	0.59	0.60	6	5						95	0.08		5		95
CC25	Sierra Gardens Drive	0.05	150	151	0.27	0.15	3.8	1	0.019	0.49	0.14	0.66	52	30	40	0	0	0	0	30	0.12		5	20	75
CC30	Loretto Drive	0.15	148	150	0.27	0.27	7.5	1	0.018	0.48	0.14	0.67	55	50	10	10				30	0.15		35	5	60
CC35	Oak Ridge Drive	0.13	140	148	0.42	0.17	19.2	1	0.019	0.50	0.13	0.64	48	20	40	20				20	0.13		20		80
CC40	Linda Creek	0.16	130	140	0.53	0.23	18.9	1	0.017	0.45	0.14	0.73	66	40	50					10	0.15		25		75
CC45	Dry Creek	1.12	120	160	1.17	0.59	34.1	1	0.020	0.51	0.25	0.62	44	15	40	20				25	0.12		10		90
SR1	Barton Road	1.16	320	420	1.74	0.38	57.4	4	0.081	2.11	0.94	0.60	12			5	5	40	30	20	0.09			85	15
SR5	Sierra College Blvd	1.77	215	350	2.08	0.95	64.8	4	0.117	3.05	1.92	0.60	4					10	10	80	0.09	5	5	20	70
SR8	East Roseville Parkway	0.19	200	215	0.42	0.23	36.0	3	0.104	2.70	0.69	0.60	2						5	95	0.07				100
SR10	East Roseville Parkway	0.45	200	230	0.95	0.61	31.7	3	0.063	1.63	0.77	0.60	12	5			30			65	0.09				100
SR15	Eureka Road	0.17	190	200	0.38	0.30	26.4	3	0.110	2.86	0.82	0.60	2					0		100	0.07				100
SR20	McLaren Drive	0.28	150	190	0.72	0.38	55.6	3	0.060	1.56	0.52	0.60	14	10		10				80	0.10		20		80
SR25	Linda Creek	0.05	141	150	0.19	0.09	47.5	3	0.057	1.48	0.21	0.60	16			50				50	0.14		45		55
MR1	Rock Springs Road	0.50	740	830	0.72	0.42	125.1	4	0.103	2.68	0.81	0.60	6						50	50	0.13		50	50	
MR5	King Road	1.44	630	740	1.06	0.57	103.7	4	0.103	2.68	1.05	0.60	6						50	50	0.10		15	85	
MR10	Horseshoe Bar Road	1.05	555	630	0.95	0.61	79.2	4	0.134	3.49	1.41	0.60	3						10	90	0.09			95	5
MR15	Dick Cook Road	2.12	479	635	1.70	0.80	91.5	4	0.101	2.62	1.37	0.60	6				20	0	10	70	0.10	0	3	90	7
MR19	Lake Trib.	1.59	418	495	1.67	0.95	46.2	4	0.099	2.56	1.58	0.60	7					0	60	40	0.09	0	0	92	8
MR20	Conf. with MR19 Trib.	2.18	418	479	1.89	1.29	32.2	4	0.098	2.54	1.92	0.60	7					20	30	50	0.09	0	3	83	14

TABLE 2-3 (Continued)

Basin ID	Basin Description	Basin Area (sq mi)	Chan DElev (ft)	Basin UElev (ft)	Basin Length (mi)	Basin Centrd (mi)	Basin Slope (ft/mi)	Basin Type (Tab2-4)	Basin 'n'	Basin Ct	Basin Lag (hr)	Basin Cp	Imp Area (%)	1986 Land Use Conditions: Comm 0.90	HDR 0.60	MDR 0.30	LDR 0.20 (%)	RLDR 0.15	RR/RE 0.10	Open 0.02	Loss Rates (in/hr)	Soil Classification: A:.48 A:.31	B:.25 B:.16	C:.16 C:.09	D:.12 D:.07
MR21	Cavitt Stallman Road	1.39	380	418	0.72	0.38	52.8	4	0.095	2.48	0.84	0.60	8					30	20	50	0.09			96	4
MR24	Barton Road	1.23	380	475	1.40	0.83	67.8	4	0.103	2.68	1.40	0.60	6						50	50	0.09		3	93	4
MR25	Sierra College Blvd	1.39	240	380	2.08	1.17	67.2	4	0.095	2.47	1.65	0.60	8						70	30	0.08		4	56	40
MR29	Auburn-Folsom Road	1.26	370	450	1.25	0.21	64.0	4	0.081	2.12	0.68	0.60	12			10	10	40		40	0.10			94	6
MR30	Barton Road	1.75	310	420	2.46	1.33	44.7	4	0.088	2.28	1.80	0.60	10					15	70	15	0.09			94	6
MR31	Sierra College Blvd	1.70	240	345	2.08	0.89	50.4	4	0.086	2.23	1.43	0.60	10			5		15	60	20	0.09			60	40
MR35	Boardman Trib.	1.00	182	438	2.31	1.17	110.8	3	0.110	2.86	1.83	0.60	2							100	0.07				100
MR36	Conf. w/Boardman Trib.	0.71	182	240	1.89	1.14	30.6	3	0.110	2.86	2.09	0.60	2							100	0.08	0	6	0	94
MR37	Conf. with Secret Rav.	0.16	160	182	0.68	0.42	32.3	3	0.110	2.86	1.06	0.60	2							100	0.10		28	0	72
MR40	Mouth of Miners Ravine	0.38	140	160	0.61	0.34	33.0	3	0.058	1.51	0.50	0.60	15	15						85	0.12	10	20		70
SE1	Gilardi Road	1.54	540	730	1.27	0.72	149.7	4	0.151	3.92	1.66	0.60	2						0	100	0.07	0	0	5	95
SE5	E. Fk Penryn at Sec. R.	0.57	495	700	1.17	0.85	174.6	4	0.101	2.63	1.12	0.60	6	2	3				10	85	0.09		10	20	70
SE7	Rock Springs Road	0.40	470	495	0.27	0.19	94.3	4	0.151	3.92	0.69	0.60	2	0	0	0	0	0	0	100	0.10	0	19	57	24
SE10	Conf. w/E. Fk Penryn Trib.	0.49	495	540	0.57	0.28	79.2	4	0.103	2.68	0.71	0.60	6						50	50	0.08		5	50	45
SE15	Boulder Creek Road	0.74	400	470	0.83	0.57	84.0	4	0.134	3.49	1.31	0.60	3						10	90	0.11	6	9	65	20
SE20	Newcastle Road	2.03	760	1200	1.52	0.91	290.4	4	0.106	2.75	1.20	0.60	6		2				30	68	0.12		45	25	30
SE25	Brennans Road	0.84	640	760	1.25	0.45	96.0	4	0.123	3.20	1.25	0.60	4						20	80	0.11		24	71	5
SE26	Boulder Creek Road	0.70	400	640	1.59	0.76	150.9	3	0.099	2.57	1.20	0.60	3						10	90	0.09		8	74	18
SE30	King Road	0.67	378	400	0.80	0.42	27.7	3	0.074	1.92	0.77	0.60	7	3					30	67	0.10		10	70	20
SE35	Conf. with King Rd. Trib.	0.34	352	378	0.76	0.42	34.3	3	0.104	2.70	1.03	0.60	2						5	95	0.08			55	45
SE40	Horseshoe Bar Road	1.14	351	440	1.59	1.52	55.9	4	0.071	1.86	1.28	0.60	17	15					25	60	0.10		3	76	21
SE44	King R. Trib. at Val Verde R.	0.90	438	680	1.52	0.95	159.7	3	0.091	2.38	1.16	0.60	4						20	80	0.10		17	70	13
SE45	King Rd. Trib. at Secret Rav.	2.27	352	438	1.14	1.14	75.7	3	0.075	1.94	1.04	0.60	7						60	40	0.09		7	83	10
SE50	Loomis City Boundary	1.83	319	351	0.91	0.45	35.2	3	0.099	2.57	1.07	0.60	3						10	90	0.09		1	82	17
SE51	Sierra College Blvd	1.03	280	319	0.76	0.38	51.5	3	0.099	2.57	0.89	0.60	3						10	90	0.09		5	84	11
SE52	Rocklin Road	0.47	260	280	1.29	0.76	15.5	3	0.054	1.39	0.88	0.60	20	20			0	0	0	80	0.14	3	50	3	44
SE55	Aquilar Trib. at Sierra Coll. Bd.	1.11	300	355	1.40	1.14	39.2	3	0.099	2.57	1.64	0.60	3						10	90	0.09		8	77	15
SE56	Aguilar Trib. at Sec. Rav.	0.73	260	300	0.91	0.42	44.0	3	0.062	1.61	0.62	0.60	12	0	5	20	0	15	0	60	0.11		2	89	9
SE57	Conf. with Sucker Ravine	0.19	215	250	0.53	0.30	66.0	3	0.110	2.86	0.78	0.60	2	0	0	0			0	100	0.10			68	32
SE60	Sucker R./E. Trib. at Sucker R	0.66	280	350	1.67	1.06	42.0	3	0.049	1.26	0.82	0.60	27	15	20	0	0			65	0.12		12	88	
SE65	Sucker Rav. at King Rd.	0.34	350	415	0.76	0.23	85.8	3	0.044	1.14	0.31	0.60	37	10	40	10	0	0	0	40	0.12		0	72	28
SE66	Sucker R. at Conf. w/E. Trib.	0.97	280	340	1.93	1.33	31.1	3	0.067	1.74	1.35	0.60	10				20		50	30	0.11		3	96	1
SE70	Sucker R. at Rocklin Rd	0.70	260	280	1.14	0.76	17.6	3	0.045	1.18	0.70	0.60	33	25		15		40		20	0.13	8	10	22	60
SE78	Sucker Ravine at I-80	0.22	215	260	0.64	0.34	69.9	3	0.048	1.24	0.37	0.60	28	5	10	45	0	0	40		0.11		0	20	80
SE80	Rocklin City Boundary	0.81	180	215	1.21	0.57	28.9	4	0.072	1.87	0.95	0.60	17	5		30		15		50	0.10		10	5	85
SE85	Mouth of Secret Ravine	0.72	160	180	1.14	0.91	17.6	3	0.072	1.86	1.17	0.60	8	5		5				90	0.09	3	7		90
AC1	CTR Trib. at Cl. Tun. Rd	0.64	550	698	0.76	0.45	195.4	4	0.151	3.92	1.15	0.60	2						0	100	0.07	0	0	12	88
AC2	CTR Trib. at English Col.	1.20	490	550	1.06	0.53	56.6	4	0.151	3.92	1.66	0.60	2						0	100	0.07	0	0	16	84
AC4	CTR Trib. at Colwell Rd	0.45	445	490	0.57	0.38	79.2	4	0.100	2.60	0.76	0.60	7			0	5	0	45	50	0.10	0	12	63	25
AC5	CTR Trib. Conf. w/Humphrey	1.61	379	575	1.70	0.83	115.0	4	0.089	2.31	1.18	0.60	9						90	10	0.10		15	80	5
AC10	CTR Trib. Conf. w/Antel. Cr.	0.30	339	379	1.10	0.57	36.4	4	0.086	2.24	1.06	0.60	10	0	0	0	0	0	100	0	0.11	0	29	60	11
AC15	English Colony Road	0.58	430	475	0.42	0.42	108.0	4	0.099	2.56	0.66	0.60	7						60	40	0.09			75	25
AC16	Colwell Road	0.54	420	430	0.61	0.38	16.5	4	0.095	2.47	0.96	0.60	8						70	30	0.09			97	3
AC20	Citrus Colony Road	0.66	365	420	0.57	0.32	96.8	4	0.086	2.24	0.60	0.60	10						100		0.09		2	92	6
AC25	Conf w/Clark Tun. Rd Trib.	0.54	339	365	0.98	0.53	26.4	4	0.111	2.89	1.36	0.60	5	2				8		90	0.10		8	84	8
AC30	Delmar Avenue/Loomis	0.94	290	339	1.17	0.72	41.7	3	0.078	2.02	1.03	0.60	6						50	50	0.10		10	80	10
AC35	Conf w/Clover Val. Cr.	1.02	222	290	1.63	1.10	41.7	3	0.054	1.40	0.92	0.60	19	10	0	30		0	0	60	0.11	0	5	65	30

TABLE 2-3 (Continued)

Basin ID	Basin Description	Basin Area (sq mi)	Chan DElev (ft)	Basin UElev (ft)	Basin Length (mi)	Basin Centrd (mi)	Basin Slope (ft/mi)	Basin Type (Tab2-4)	Basin 'n'	Basin Ct	Basin Lag (hr)	Basin Cp	Imp Area (%)	1986 Land Use Conditions (%): Comm 0.90	HDR 0.60	MDR 0.30	LDR 0.20	RLDR 0.15	RR/RE 0.10	Open 0.02	Loss Rates (in/hr)	Soil Classification: A:.48 A:.31	B:.25 B:.16	C:.16 C:.09	D:.12 D:.07
AC40	Sunset Blvd	1.27	200	240	1.44	0.61	27.8	3	0.046	1.21	0.67	0.60	31	10	20	30				40	0.11		5		95
AC41	Rocklin City Boundary	0.75	200	205	0.98	0.66	5.1	3	0.047	1.23	0.82	0.60	29	10	15	35	0			40	0.11		8	2	90
AC45	Mouth of Antelope Cr.	0.77	140	200	2.20	1.29	27.3	3	0.063	1.63	1.33	0.60	12	8	5	0				87	0.08		8		92
CV1	English Colony Road	1.18	515	635	0.95	0.95	126.7	4	0.151	3.92	1.70	0.60	2							100	0.08			35	65
CV5	Wood Glen Drive	0.95	370	515	2.01	0.87	72.2	4	0.151	3.92	2.33	0.60	2							100	0.08		8	17	75
CV6	Creekwood Drive	0.95	270	370	1.97	1.14	50.8	4	0.121	3.14	2.14	0.60	4				10			90	0.09		13	29	58
CV10	Mouth of Clover Valley	0.54	222	270	1.25	0.98	38.4	3	0.063	1.64	0.96	0.60	12			25	15			60	0.10		8	2	90
DC4	Parry Street	0.67	130	140	0.76	0.42	13.2	3	0.039	1.03	0.46	0.66	52	30	40					30	0.14		24		76
DC5	Conf. with Cirby Cr.	0.60	120	130	1.17	0.80	8.5	3	0.039	1.00	0.69	0.68	56	35	35	10				20	0.13		15	15	70
DC10	Vernon Avenue	0.72	115	160	0.95	0.19	47.5	2	0.030	0.79	0.24	0.62	44	15	20	60				5	0.14		15		85
DC15	SPRR Bridge	0.89	114	160	1.52	0.76	30.4	2	0.032	0.83	0.49	0.60	38	20	15	35				30	0.11				100
DC20	Conf. with DC25/DC80 Tribs.	1.15	96	160	2.35	1.17	27.3	2	0.032	0.83	0.67	0.60	38	35	5	0	0	20	0	40	0.12		25		75
DC25	Dry Creek DC25 Trib.	1.71	96	150	2.23	1.59	24.2	2	0.038	1.00	0.90	0.60	21	5	10	25			20	40	0.13		40		60
DC35	Cook Riolo Road	0.36	89	96	0.38	0.17	18.5	3	0.078	2.02	0.51	0.60	6						50	50	0.09		25		75
DC40	Dry Creek DC40 Trib.	0.37	86	140	0.93	0.57	58.2	2	0.049	1.27	0.52	0.60	10					60	0	40	0.08	0	10		90
DC45	Conf. with DC40 Trib.	0.27	86	89	0.38	0.27	7.9	3	0.068	1.77	0.59	0.60	9					55		45	0.12		50		50
DC50	Conf. with DC55 Trib.	0.46	79	86	0.76	0.61	9.2	3	0.081	2.11	1.13	0.60	5					25		75	0.12		60		40
DC55	Dry Creek DC55 Trib.	0.69	80	130	1.10	0.64	45.5	3	0.075	1.96	0.93	0.60	7			5		25		70	0.08		10		90
DC60	Conf. with DC65 Trib.	0.87	72	79	1.46	0.57	4.8	3	0.075	1.96	1.42	0.60	7	0	8	0	0	0	0	92	0.11	0	35		65
DC65	Dry Creek DC65 Trib.	1.28	72	120	2.01	1.42	23.9	3	0.071	1.86	1.56	0.60	8					45		55	0.09	0	20	0	80
DC68	Cty Line Trib. at PFE Road	1.35	90	155	2.73	1.40	23.8	3	0.085	2.20	2.03	0.60	5	0				20	0	80	0.07				100
DC70	Cty Line Trib. at Watt Ave.	0.44	74	90	0.95	0.76	16.9	3	0.110	2.86	1.61	0.60	2	0					0	100	0.09	0	25	0	75
DC71	Mouth of Cty Line Trib.	0.27	69	100	0.66	0.38	46.8	3	0.081	2.10	0.70	0.60	5	2					20	78	0.08		15		85
DC75	Watt Avenue	0.68	70	150	1.14	0.64	70.4	3	0.110	2.86	1.28	0.60	2					0	0	100	0.11		40		60
DC76	Conf with Cty Line Trib.	0.42	69	110	0.83	0.47	49.2	3	0.101	2.62	1.01	0.60	3					5		95	0.10	0	30	0	70
DC80	Cook Riolo Road	1.97	96	157	2.41	1.14	25.4	2	0.033	0.87	0.71	0.60	32	30					50	20	0.09		5		95
DC85	Conf. with DC90 Trib.	0.32	64	69	0.80	0.53	6.3	3	0.072	1.86	1.03	0.60	8	5		5				90	0.13		60		40
DC90	Dry Creek DC90 Trib.	0.69	64	97	1.55	1.14	21.2	3	0.075	1.94	1.42	0.60	7	5					5	90	0.08		5		95
DC95	Sierra Cr. at Walerga Rd	0.91	105	150	1.33	0.72	33.9	3	0.075	1.96	1.08	0.60	7			15			5	80	0.08				100
DC96	Sierra Cr. at Watt Ave.	1.45	73	150	1.70	0.64	45.2	3	0.068	1.78	0.98	0.60	9			25				75	0.08				100
DC100	Mouth of Sierra Creek	0.54	63	73	1.33	0.64	7.5	3	0.055	1.44	0.98	0.60	18	5	10	20			0	65	0.09				100
DC105	Dry Creek DC105 Trib.	1.06	54	89	1.70	0.98	20.5	3	0.057	1.48	1.07	0.60	16	5		35		0	0	60	0.09				100
DC110	Conf with Sierra Creek	0.26	63	85	0.76	0.11	29.0	3	0.057	1.48	0.38	0.60	16			50				50	0.14		40		60
DC115	Conf with DC105 Trib.	0.32	54	63	0.42	0.23	21.6	3	0.061	1.58	0.44	0.60	13			40				60	0.13		35		65
DC120	Q Street	0.53	52	75	0.66	0.38	34.7	3	0.070	1.81	0.64	0.60	9				0	50	0	50	0.13				
DC125	Elkhorn Blvd	1.37	45	52	1.59	0.98	4.4	3	0.062	1.60	1.45	0.60	13	0	0	0	30	40	0	30	0.12	0	35	0	65
DC130	Rio Linda Blvd	0.91	37	45	1.17	0.83	6.8	3	0.060	1.56	1.13	0.60	14	5		20	10	0		65	0.14	0	55	0	45
DC135	Natomas E Main Drain	1.04	27	37	1.67	1.25	6.0	3	0.069	1.81	1.71	0.60	9	0		0	15	30	0	55	0.11	0	30	5	65

Unit Hydrograph Parameters. Each subbasin in the watershed was described hydrologically using the parameters listed in the following paragraphs.

Basin Area. The subbasin areas for input into the model were taken from USGS 1:24,000 scale topographic maps using a planimeter.

Lengths. The lengths along the longest watercourse and along the main channel within each subbasin were measured using a map wheel on the same maps used for basin area determination. The centroid of each subbasin was estimated based on subbasin shape.

Slopes. The slope of the subbasin and of the main channel in the subbasin are dependent on the lengths of the longest watercourse and of the main channel, as described above, and the elevation of the upstream and downstream ends of the longest watercourse and the main channel. The elevations at the upstream and downstream end of the main channel and the longest watercourse in each subbasin were read off the USGS topographic maps.

Loss Rates. Soil maps from the Soil Conservation Service (SCS) were used to determine the hydrologic soil types in the watershed. A list of most of the soils in the United States with the hydrologic soil group classification for each soil is provided in the SCS manual TR55. This list was used to color code the SCS soil maps covering the Dry Creek watershed by hydrologic soil type. Subbasin outlines were placed over the soil maps and the approximate percentage of each soil group in each subbasin was determined and entered into the spreadsheet. Loss rates for each soil group, based on the soil infiltration rate and the assumed ground cover for each land use in the subbasin, is calculated as described previously. A weighted loss rate for each of the subbasins is calculated in the spreadsheet and put into the model. The loss rates used for the urban landscaping assumed for the developed areas are 0.48, 0.25, 0.16, and 0.12 inches per hour for soil types A, B, C, and D respectively. The corresponding loss rates used for annual grasses in undeveloped areas are 0.31, 0.16, 0.09, and 0.07.

Effective Impervious Area. The effective impervious area for a subbasin is defined as the percentage of the area that is impervious and which does not drain across a neighboring pervious area. The effective impervious area for each subbasin is based on averages for a given land use description, and was determined by estimating the percentage of the subbasin contained in each type of land use discussed in Chapter 1. Current land use was estimated using a combination of aerial photographs and general plan maps with overlays of the subbasin boundaries. Future land use was determined entirely from the general plan maps. In order to go from land use to effective impervious area, an imperviousness factor had to be assumed for each land use as shown in Table 2-4.

Basin 'n'. Basin 'n' values for the subbasins in the Dry Creek watershed range from a low of around 0.018, in subbasins with a high percentage of commercial development and well-developed channels, to a high of around 0.130 in subbasins with very low density development and/or open space combined with dense vegetation in the channels and floodplains.

TABLE 2-4

SUBBASIN 'N', C_p, AND EFFECTIVE IMPERVIOUS

Basin 'n' by Type Channel/Floodplain Description						Effective Impervious	
1 Pipe/ Conc.	2 Grass/ Earth	3 Open Woods	4 Dense Veg.	Snyder C_p	Basin Land Use	Low	High
0.015	0.023	0.032	0.040	0.85	Commercial/Highways/Parking Lots	0.80	0.99
0.016	0.024	0.033	0.042	0.80	Apartments/Offices/Mobile Homes	0.70	0.90
0.018	0.026	0.035	0.044	0.75	Condominiums/Schools/Industrial	0.50	0.70
0.020	0.028	0.037	0.046	0.70	Residential 8-10 Houses per Acre	0.45	0.60
0.022	0.030	0.039	0.048	0.65	Residential 6-8 Houses per Acre	0.35	0.50
0.024	0.032	0.041	0.050	0.60	Residential 4-6 Houses per Acre	0.30	0.40
0.026	0.034	0.044	0.055	0.60	Residential 3-4 Houses per Acre	0.20	0.30
0.028	0.037	0.048	0.060	0.60	Residential 2-3 Houses per Acre	0.15	0.25
0.030	0.040	0.052	0.065	0.60	Residential 1-2 Houses per Acre	0.10	0.20
0.032	0.045	0.058	0.075	0.60	Residential 1-2 Acres per House	0.07	0.15
0.035	0.050	0.070	0.090	0.60	Residential 2-5 Acres per House	0.05	0.10
0.040	0.060	0.090	0.120	0.60	Rural Residential/Rural Estates	0.02	0.05
0.050	0.080	0.110	0.150	0.60	Open Space (undeveloped)	0.01	0.02

Notes:

1. Low effective impervious is appropriate for 2-year and less recurrence interval events. High effective impervious is appropriate for 10-year and greater recurrence interval events.
2. If suitable land use description cannot be found in table, basin 'n' is a weighted average, by length of a typical flow path, using Manning's 'n' for expected depths for overland flow, gutters, storm drains, channels, and floodplains.
3. System constraints due to undersized inlets and storm drains cause temporary flooding in streets and will increase basin lag time and should be taken into account when determining basin n.

The 'n' values for the study subbasins were determined using Table 2-4. In this table, the subbasin 'n' value is chosen by selecting the row in the table that has land use matching the subbasin weighted land use. This weighted land use was determined in the spreadsheet by weighting the effective impervious area for each of the land use types in the basin and then using that effective impervious area to determine which line of Table 2-4 to use. The subbasin 'n' is then selected from one of four columns of 'n' values based on the condition of the channels and floodplains in the subbasin. Determination of the channel/floodplain type was based on examination of infrared and normal aerial photography and actual visits to the watershed.

CALIBRATION OF MODEL

Calibration of a model is the process used to insure that the model predicts actual system behavior as closely as possible. In model calibration, known input data for a historical event, such as the February 1986 flood, is entered into the model and the output from the model is compared with the known flood conditions. Parameters in the model are then adjusted until the model output matches historic data for the event.

The HEC-1 model of the Dry Creek watershed was calibrated to observed flows and high water marks for flood events occurring in February 1986 and March 1989. Peak flows in the February 18-19, 1986 event had recurrence intervals for most of the Dry Creek watershed of from 50 to 100 years. Peak flows in the March 25, 1989, event had recurrence intervals of from 1 to 2 years.

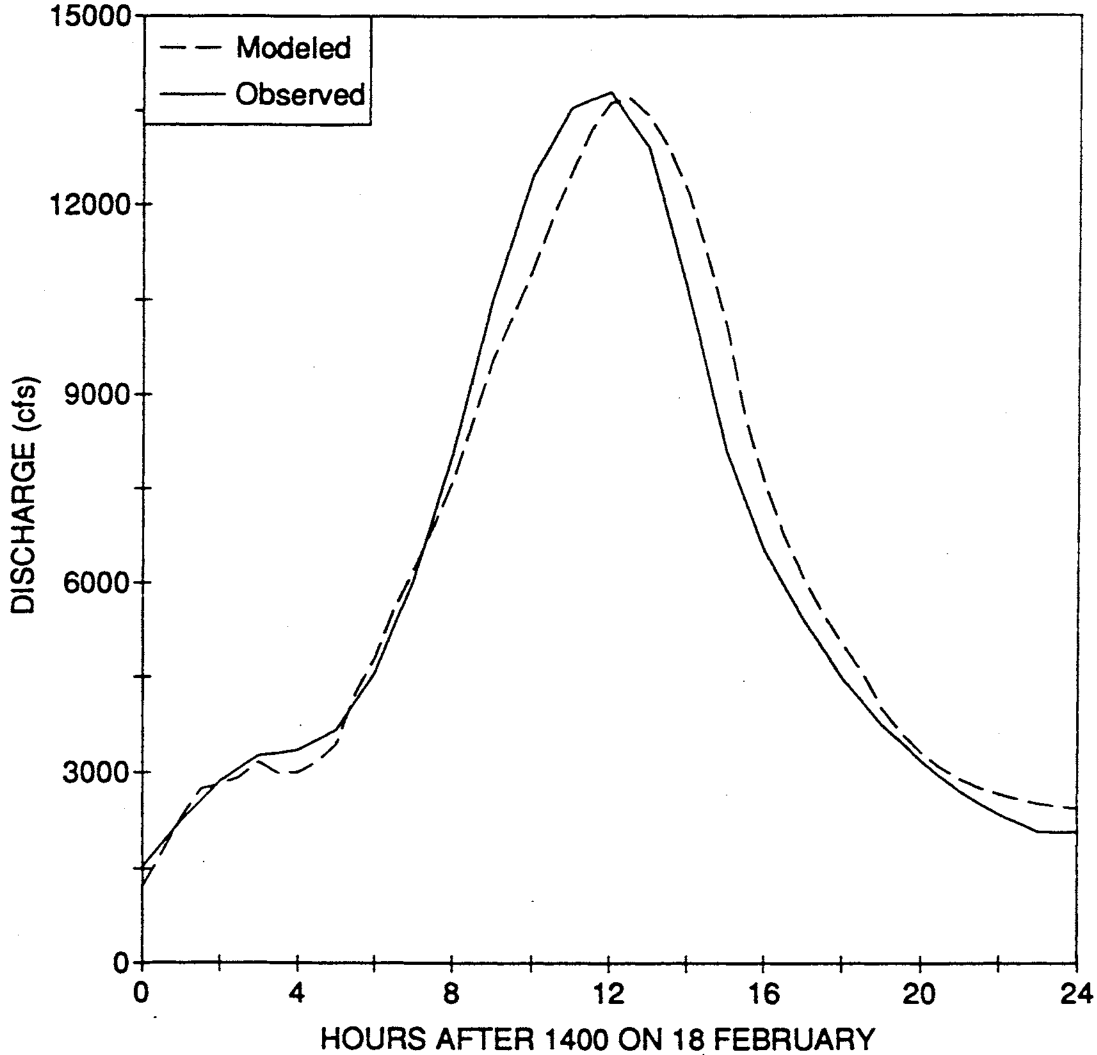
Flood of February 1986

It was fortunate that precipitation and flow data, from high water marks and the Dry Creek gage at Vernon Street, was available for the February 1986 event, since its recurrence interval was close to the 100-year recurrence interval that is of primary importance to this study. Fifteen-minute precipitation data for this event were available for rain gages at the City of Roseville, Roseville filtration plant, Sierra College, National Weather Service (NWS) ALERT gages at Auburn and Folsom, and Sacramento County ALERT gages at Orangevale, Navion, and Sunrise Boulevard. Figure 2-3 indicates the streamgage and rain gage locations used in calibrating the February 1986 event. A continuous gage record was available at Dry Creek at Vernon Street in the City of Roseville. High water marks at numerous road crossings, combined with HEC-2 analyses of those road crossings provided a basis for estimating peak flows at those locations.

The calibration process for the February 1986 event primarily involved modification of channel reach routing parameters in the HEC-1 and HEC-2 models to match observed high water marks at many locations and to also match the stage record at the Vernon Street gage. Unit hydrograph parameters, loss rates, and initial conditions were set for observed land use and saturated soil conditions as described in earlier sections. Observed land use was obtained from 1986 aerial photographs of the watershed. Figure 2-5 shows the model calibration results at the Dry Creek at Vernon Street streamgage. This calibration was quite good considering the inherent inaccuracy in the stage rating curve for the Vernon Street gage. The stage rating curve for flows over 3,000 cfs was based on the HEC-2 model of flow through the SPRR subway bridge culverts. Observed high water marks at various locations throughout the watershed were also closely matched, usually within ± 0.5 feet.

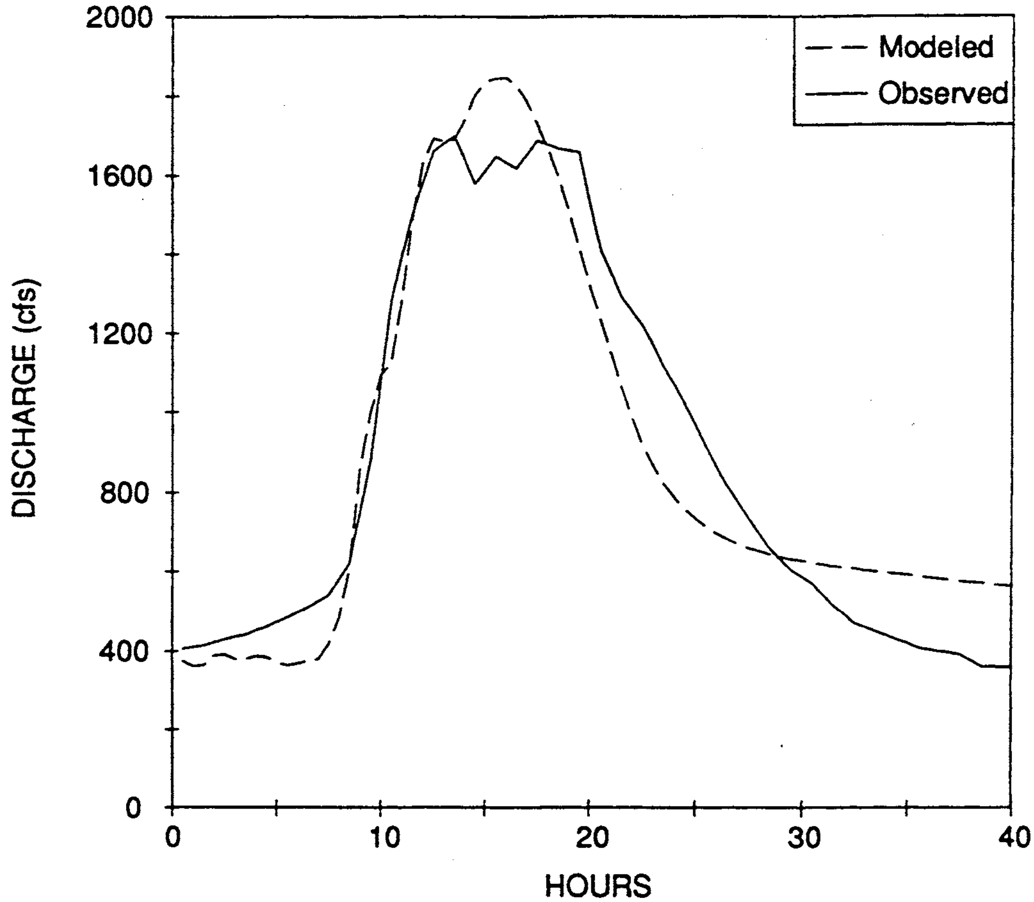
Flows of March 1989

The HEC-1 model was also calibrated to the much lower magnitude March 25, 1989, event that had a recurrence interval of 1-2 years. In March 1989, rain gage records were also available at Roseville and Sacramento County ALERT stations that were installed after 1986. These additional station locations are also shown in Figure 2-3. As expected, calibration of the HEC-1 model for a 1-2 year recurrence event required higher initial losses and constant loss rates reflecting partly saturated soil conditions. Results of the March 25, 1989, calibration for the Dry Creek gage at Vernon Street are shown on Figure 2-6. Streamgage stage information was available from several Roseville and Sacramento County ALERT stations for this event, but because of a lack of storms since their installation, the rating curves for the gages had not been verified and were inadequate for use in calibration.



FEBRUARY 1986 MODEL CALIBRATION AT VERNON STREET GAGE

FIGURE 2-5



MARCH 1989 MODEL CALIBRATION AT VERNON STREET GAGE

FIGURE 2-6

BASE CONDITION (1989) MODEL

The year 1989 was chosen as the base condition for this study because of the ready availability of good aerial photography of the entire watershed, and the unavailability of more recent photos. As described in previous sections, data describing the hydrologic characteristics of each of the subbasins for the February 1986 event, is contained in Table 2-3. Once the HEC-1 model was calibrated for the February 1986 event, changes were made in the spreadsheet to reflect the changes in the watershed that had occurred between 1986 and 1989. These changes mostly involved changes in land use, channel and flood plain descriptions, and basin 'n' values, because of development in portions of the watershed.

Subbasin land use descriptions were taken from aerial photographs of the Dry Creek watershed taken in the spring and summer of 1989, correlated with General Plan land use designations as described in previous sections. Channel and floodplain descriptions for determining subbasin 'n' type were based on the aerial photography and personal visits to each of the locations where streams cross roadways in the watershed. Table 2-5 contains the hydrologic data for the 1989 base condition.

Precipitation for each of the design storm recurrence intervals, 100-, 25-, 10-, and 2-year was developed as described above in the section on precipitation. This precipitation was then applied to the HEC-1 model that had been modified to represent the 1989 base conditions.

FUTURE CONDITION (GENERAL PLAN) MODEL

Modifying the 1989 base model for the General Plan Future condition runs mainly involved the changes in land use from the base condition to the Future condition. Land use values were changed in the spreadsheet to match the land use from the various general plans. Where the change in land use was extensive enough to warrant a change in the channel and floodplain description used to determine basin 'n', that parameter was also modified in the spreadsheet. The changes in land use and channel/floodplain description affected the unit hydrograph parameters of subbasin 'n', lag time (T_p), and peaking coefficient (C_p); the effective impervious area of the subbasin; and the constant loss rates because of the change in cover type that occurs with development. Table 2-6 contains the Future Condition hydrologic data for each of the subbasins.

Initially, the future condition model did not include any changes in the routing parameters of the main channels because of general plan policies that prohibit clearing of vegetation in flood plains. Through discussions with personnel from the various jurisdictions in the watershed, it became apparent that 100 percent enforcement of such a policy was not probable. Therefore, it was necessary to assume that hydrologically significant floodplain clearing will occur along 40 percent of the channels passing through areas with a development density greater than one unit per five acres. Figure 2-7 illustrates the differences between flood hydrographs based on 1989 land use, buildout land use only, and buildout land use along with floodplain clearing (the assumed Future condition).

MODEL RESULTS

The model setups described above were used to make HEC-1 model runs for the major points of interest in the watershed, such as culverts, bridges, problem areas, and tributary confluences. The 2-, 10-, 25-, 100-, 200-, and 500-year peak flows for 1989 and Future conditions at each of these locations are listed in Table 2-7. Figures 1-7a to 1-7e indicate the locations for the peak flows listed in Table 2-7. Flood hydrographs for the 10-, 25-, 100- and

TABLE 2-5

1989 BASE CONDITION SUBBASIN HYDROLOGIC DATA

Basin ID	Basin Description	Basin Area (sq mi)	Chan DElev (ft)	Basin UElev (ft)	Basin Length (mi)	Basin Centrd (mi)	Basin Slope (ft/mi)	Basin Type (Tab2-4)	Basin 'n'	Basin Ct	Basin Lag (hr)	Basin Cp	Imp Area (%)	1989 Land Use Conditions (%): Comm 0.90	HDR 0.60	MDR 0.30	LDR 0.20	RLDR 0.15	RR/RE 0.10	Open 0.02	Loss Rates (in/hr)	SCS Soil Classification: A:.48 A:.31	B:.25 B:.16	C:.16 C:.09	D:.12 D:.07
LC1	Auburn-Folsom Road	0.57	380	460	1.14	0.64	70.4	4	0.063	1.64	0.73	0.60	25	5	0	40	10	40	0	5	0.12			75	25
LC5	Barton Road	0.95	320	380	1.10	0.53	54.6	4	0.075	1.96	0.85	0.60	15	2	2	0	0	76	0	20	0.09			65	35
LC10	Wedgewood Drive	0.25	300	320	0.64	0.19	31.1	3	0.101	2.62	0.74	0.60	3	0	0	0	0	5	0	95	0.07			15	85
LC15	Cherry Avenue	1.55	230	300	1.36	0.76	51.3	3	0.081	2.11	1.11	0.60	5	0	0	0	0	25	0	75	0.11		40		60
LC20	Walnut Avenue	0.45	220	260	0.76	0.57	52.8	3	0.053	1.38	0.54	0.60	20	0	0	35	0	65	0	0	0.14		55		45
LC25	Walnut Avenue	0.41	220	330	0.91	0.76	121.0	3	0.055	1.43	0.57	0.60	18	0	0	20	0	80	0	0	0.09		10		90
LC30	Oak Avenue	0.32	195	220	1.17	0.76	21.3	3	0.064	1.87	0.97	0.60	11	0	0	0	0	70	0	30	0.13		70		30
LC35	Oak Avenue	1.12	210	251	1.29	0.49	31.8	3	0.056	1.45	0.70	0.60	17	0	0	15	0	85	0	0	0.11		35		65
LC40	Hazel Avenue	0.87	195	230	1.48	1.14	23.7	3	0.062	1.61	1.13	0.60	12	0	0	0	0	80	0	20	0.12		50		50
LC45	Indian Creek Drive	1.18	170	220	1.44	0.49	34.7	3	0.060	1.56	0.77	0.60	14	0	0	5	0	80	0	15	0.08		5		95
LC50	Treelake Road	0.84	240	345	1.29	0.85	81.5	3	0.076	1.98	0.99	0.60	6	0	0	0	0	0	55	45	0.08			35	65
LC55	Sierra College Blvd	0.89	197	240	0.98	0.61	43.7	3	0.110	2.86	1.29	0.60	2	0	0	0	0	0	0	100	0.08		15	5	80
LC60	Linda Creek	0.30	168	197	1.17	0.68	24.7	3	0.064	1.65	0.90	0.60	11	0	0	0	0	60	20	20	0.09		20		80
LC65	Country Lake Drive	0.43	180	220	0.72	0.53	55.6	3	0.058	1.50	0.56	0.60	15	0	0	3	0	97	0	0	0.11		45		55
LC70	Old Auburn Road	0.18	168	170	0.59	0.30	3.4	3	0.058	1.52	0.70	0.60	15	0	0	0	0	100	0	0	0.07				100
LC80	Champion Oaks Drive	0.98	149	230	1.29	0.19	62.9	3	0.053	1.38	0.44	0.60	20	0	0	60	0	10	0	30	0.12		15		85
LC82	Strap Ravine	0.09	141	149	0.27	0.15	30.2	3	0.046	1.21	0.24	0.60	31	0	40	20	0	0	0	40	0.13		25		75
LC85	Rocky Ridge Drive	0.26	140	141	0.57	0.08	1.8	3	0.044	1.13	0.37	0.60	38	0	40	45	0	0	0	15	0.14		20		80
LC90	Oak Ridge Drive	0.46	133	140	0.95	0.57	7.4	3	0.044	1.14	0.67	0.60	37	0	50	20	0	0	0	30	0.14		30		70
LC95	Cirby Creek	0.16	130	133	0.42	0.23	7.2	3	0.036	0.94	0.31	0.75	69	50	40	0	0	0	0	10	0.17		40		60
CC1	Douglas Boulevard	0.38	230	260	0.87	0.38	34.4	3	0.085	2.20	0.85	0.60	5	0	0	0	10	0	10	80	0.08			5	95
CC2	Douglas Boulevard	0.25	195	220	0.49	0.38	50.8	3	0.076	1.98	0.60	0.60	6	5	0	0	0	0	0	95	0.07				100
CC5	East Roseville Parkway	0.20	195	270	0.27	0.27	282.9	2	0.034	0.88	0.14	0.60	31	20	20	0	0	0	0	60	0.11		15		85
CC10	Huntington Drive	0.24	151	190	0.42	0.08	93.6	2	0.034	0.87	0.13	0.60	32	10	15	45	0	0	0	30	0.15		35		65
CC15	Sierra Gardens Drive	0.15	150	151	0.21	0.09	4.8	2	0.028	0.73	0.15	0.69	57	10	80	0	0	0	0	10	0.13		15		85
CC20	Douglas Boulevard	0.38	151	230	0.95	0.25	83.4	3	0.046	1.18	0.35	0.60	33	35	0	0	0	0	0	65	0.09		5		95
CC25	Sierra Gardens Drive	0.05	150	151	0.27	0.15	3.8	1	0.019	0.49	0.14	0.66	52	30	40	0	0	0	0	30	0.12		5	20	75
CC30	Loretto Drive	0.15	148	150	0.27	0.27	7.5	1	0.017	0.44	0.13	0.75	71	60	20	15	0	0	0	5	0.16		35	5	60
CC35	Oak Ridge Drive	0.13	140	148	0.42	0.17	19.2	1	0.019	0.50	0.13	0.64	48	20	40	20	0	0	0	20	0.13		20		80
CC40	Linda Creek	0.16	130	140	0.53	0.23	18.9	1	0.017	0.45	0.14	0.73	66	40	50	0	0	0	0	10	0.15		25		75
CC45	Dry Creek	1.12	120	160	1.17	0.59	34.1	1	0.020	0.51	0.25	0.62	44	15	40	20	0	0	0	25	0.12		10		90
SR1	Barton Road	1.16	320	420	1.74	0.38	57.4	4	0.073	1.89	0.85	0.60	16	5	0	5	5	40	30	15	0.10			85	15
SR5	Sierra College Blvd	1.77	215	350	2.08	0.95	64.8	4	0.083	2.15	1.35	0.60	11	5	0	10	0	10	10	65	0.10	5	5	20	70
SR8	East Roseville Parkway	0.19	200	215	0.42	0.23	36.0	3	0.104	2.70	0.69	0.60	2	0	0	0	0	0	5	95	0.07				100
SR10	East Roseville Parkway	0.45	200	230	0.95	0.61	31.7	3	0.056	1.45	0.68	0.60	17	10	0	0	35	0	0	55	0.09				100
SR15	Eureka Road	0.17	190	200	0.38	0.30	26.4	3	0.057	1.47	0.42	0.60	17	0	25	0	0	0	0	75	0.08				100
SR20	McLaren Drive	0.28	150	190	0.72	0.38	55.6	3	0.050	1.29	0.43	0.60	25	10	5	40	0	0	0	45	0.12		20		80
SR25	Linda Creek	0.05	141	150	0.19	0.09	47.5	3	0.048	1.26	0.18	0.60	27	0	0	90	0	0	0	10	0.17		45		55
MR1	Rock Springs Road	0.50	740	830	0.72	0.42	125.1	4	0.103	2.68	0.81	0.60	6	0	0	0	0	0	50	50	0.13		50	50	
MR5	King Road	1.44	630	740	1.06	0.57	103.7	4	0.103	2.88	1.05	0.60	6	0	0	0	0	0	50	50	0.10		15	85	
MR10	Horseshoe Bar Road	1.05	555	630	0.95	0.61	79.2	4	0.134	3.49	1.41	0.60	3	0	0	0	0	0	10	90	0.09			95	5
MR15	Dick Cook Road	2.12	479	635	1.70	0.80	91.5	4	0.101	2.62	1.37	0.60	6	0	0	0	20	0	10	70	0.10		3	90	7
MR19	Lake Trib.	1.59	418	495	1.67	0.95	46.2	4	0.099	2.56	1.58	0.60	7	0	0	0	0	0	60	40	0.09	0	0	92	8
MR20	Conf. with MR19 Trib.	2.18	418	479	1.89	1.29	32.2	4	0.098	2.54	1.92	0.60	7	0	0	0	0	20	30	50	0.09		3	83	14

TABLE 2-5 (Continued)

Basin ID	Basin Description	Basin Area (sq mi)	Chan DElev (ft)	Basin UElev (ft)	Basin Length (mi)	Basin Centrd (mi)	Basin Slope (ft/mi)	Basin Type (Tab2-4)	Basin 'n'	Basin Ct	Basin Lag (hr)	Basin Cp	Imp Area (%)	1989 Land Use Conditions (%): Comm 0.90	HDR 0.60	MDR 0.30	LDR 0.20	RLDR 0.15	RR/RE 0.10	Open 0.02	Loss Rates (in/hr)	SCS Soil Classification: A:.48 A:.31	B:.25 B:.16	C:.16 C:.09	D:.12 D:.07
MR21	Cavitt Stallman Road	1.39	380	418	0.72	0.38	52.8	4	0.094	2.44	0.83	0.60	8	0	0	0	0	32	21	47	0.09			96	4
MR24	Barton Road	1.23	380	475	1.40	0.83	67.8	4	0.103	2.68	1.40	0.60	6	0	0	0	0	0	50	50	0.09		3	93	4
MR25	Sierra College Blvd	1.39	240	380	2.08	1.17	67.2	4	0.095	2.47	1.65	0.60	8	0	0	0	0	0	70	30	0.08		4	56	40
MR29	Auburn-Folsom Road	1.26	370	450	1.25	0.21	64.0	4	0.078	2.04	0.66	0.60	13	0	0	10	10	50	0	30	0.10			94	6
MR30	Barton Road	1.75	310	420	2.46	1.33	44.7	4	0.088	2.28	1.80	0.60	10	0	0	0	0	15	70	15	0.09			94	6
MR31	Sierra College Blvd	1.70	240	345	2.08	0.89	50.4	4	0.083	2.15	1.38	0.60	11	0	0	5	0	30	50	15	0.09			60	40
MR35	Boardman Trib.	1.00	182	438	2.31	1.17	110.8	3	0.083	2.17	1.39	0.60	5	0	0	10	0	0	0	90	0.08				100
MR38	Conf. w/Boardman Trib.	0.71	182	240	1.89	1.14	30.6	3	0.101	2.62	1.92	0.60	3	0	0	0	0	5	0	95	0.08		6	0	94
MR37	Conf. with Secret Rav.	0.16	160	182	0.68	0.42	32.3	3	0.110	2.86	1.06	0.60	2	0	0	0	0	0	0	100	0.10		28	0	72
MR40	Mouth of Miners Ravine	0.38	140	160	0.61	0.34	33.0	3	0.058	1.51	0.50	0.60	15	15	0	0	0	0	0	85	0.12	10	20		70
SE1	Gilardi Road	1.54	540	730	1.27	0.72	149.7	4	0.151	3.92	1.66	0.60	2	0	0	0	0	0	0	100	0.07	0	0	5	95
SE5	E. Fk Penryn at Sec. R.	0.57	495	700	1.17	0.85	174.6	4	0.101	2.63	1.12	0.60	6	2	3	0	0	0	10	85	0.09		10	20	70
SE7	Rock Springs Road	0.40	470	495	0.27	0.19	94.3	4	0.151	3.92	0.69	0.60	2	0	0	0	0	0	0	100	0.10		19	57	24
SE10	Conf. w/E. Fk Penryn Trib.	0.49	495	540	0.57	0.28	79.2	4	0.103	2.68	0.71	0.60	6	0	0	0	0	0	50	50	0.08		5	50	45
SE15	Boulder Creek Road	0.74	400	470	0.83	0.57	84.0	4	0.134	3.49	1.31	0.60	3	0	0	0	0	0	10	90	0.11	6	9	65	20
SE20	Newcastle Road	2.03	760	1200	1.52	0.91	290.4	4	0.097	2.53	1.10	0.60	7	0	2	0	0	30	0	68	0.12		45	25	30
SE25	Brennans Road	0.84	640	760	1.25	0.45	96.0	4	0.123	3.20	1.25	0.60	4	0	0	0	0	0	20	80	0.11		24	71	5
SE28	Boulder Creek Road	0.70	400	640	1.59	0.76	150.9	3	0.099	2.57	1.20	0.60	3	0	0	0	0	0	10	90	0.09		8	74	18
SE30	King Road	0.67	378	400	0.80	0.42	27.7	3	0.067	1.74	0.70	0.60	10	3	0	0	15	0	30	52	0.11		10	70	20
SE35	Conf. with King Rd. Trib.	0.34	352	378	0.76	0.42	34.3	3	0.076	1.98	0.76	0.60	6	5	0	0	0	0	0	95	0.08			55	45
SE40	Horseshoe Bar Road	1.14	351	440	1.59	1.52	55.9	4	0.067	1.75	1.20	0.60	20	15	0	10	0	0	30	45	0.10		3	76	21
SE44	King R. Trib. at Val Verde R.	0.90	438	680	1.52	0.95	159.7	3	0.086	2.23	1.09	0.60	4	0	0	0	0	0	30	70	0.10		17	70	13
SE45	King Rd. Trib. at Secret Rav.	2.27	352	438	1.14	1.14	75.7	3	0.075	1.94	1.04	0.60	7	0	0	0	0	0	60	40	0.09		7	83	10
SE50	Loomis City Boundary	1.83	319	351	0.91	0.45	35.2	3	0.091	2.38	0.99	0.60	4	0	0	0	0	0	20	80	0.09		1	82	17
SE51	Sierra College Blvd	1.03	280	319	0.76	0.38	51.5	3	0.099	2.57	0.89	0.60	3	0	0	0	0	0	10	90	0.09		5	84	11
SE52	Rocklin Road	0.47	260	280	1.29	0.76	15.5	3	0.054	1.39	0.88	0.60	20	20	0	0	0	0	0	80	0.14	3	50	3	44
SE55	Aguilar Trib., Sierra Coll. Bd.	1.11	300	355	1.40	1.14	39.2	3	0.079	2.06	1.31	0.60	6	0	5	0	0	0	10	85	0.10		8	77	15
SE56	Aguilar Trib. at Sec. Rav.	0.73	260	300	0.91	0.42	44.0	3	0.062	1.61	0.62	0.60	12	0	5	20	0	15	0	60	0.11		2	89	9
SE57	Conf. with Sucker Ravine	0.19	215	250	0.53	0.30	66.0	3	0.090	2.34	0.64	0.60	4	0	0	0	10	0	0	90	0.10			68	32
SE60	Sucker R./E. Trib., Sucker R.	0.66	280	350	1.67	1.06	42.0	3	0.047	1.22	0.80	0.60	30	15	25	0	0	0	0	60	0.13		12	88	
SE65	Sucker Rav. at King Rd.	0.34	350	415	0.76	0.23	85.8	3	0.042	1.09	0.29	0.61	43	15	40	10	0	10	0	25	0.13	0	0	72	28
SE68	Sucker R. at Conf. w/E. Trib.	0.97	280	340	1.93	1.33	31.1	3	0.067	1.74	1.35	0.60	10	0	0	0	20	0	50	30	0.11		3	96	1
SE70	Sucker R. at Rocklin Rd	0.70	260	280	1.14	0.76	17.6	3	0.040	1.05	0.62	0.64	48	40	0	30	0	20	0	10	0.15	8	10	22	60
SE76	Sucker Ravine at I-80	0.22	215	260	0.64	0.34	69.9	3	0.048	1.24	0.37	0.60	28	5	10	45	0	0	40	0	0.11	0	0	20	80
SE80	Rocklin City Boundary	0.81	180	215	1.21	0.57	28.9	4	0.068	1.77	0.90	0.60	20	5	5	30	0	15	0	45	0.10		10	5	85
SE85	Mouth of Secret Ravine	0.72	160	180	1.14	0.91	17.6	3	0.072	1.86	1.17	0.60	8	5	0	5	0	0	0	90	0.09	3	7		90
AC1	CTR Trib. at Cl. Tun. Rd	0.64	550	698	0.76	0.45	195.4	4	0.151	3.92	1.15	0.60	2	0	0	0	0	0	0	100	0.07		0	12	88
AC2	CTR Trib. at English Col.	1.20	490	550	1.06	0.53	56.6	4	0.151	3.92	1.66	0.60	2	0	0	0	0	0	0	100	0.07	0	0	16	84
AC4	CTR Trib. at Colwell Rd	0.45	445	490	0.57	0.38	79.2	4	0.100	2.60	0.76	0.60	7	0	0	0	5	0	45	50	0.10		12	63	25
AC5	CTR Trib. Conf. w/Humphrey	1.61	379	575	1.70	0.83	115.0	4	0.087	2.27	1.16	0.60	10	0	0	0	5	0	85	10	0.10		15	80	5
AC10	CTR Trib. Conf. w/Antel. Cr.	0.30	339	379	1.10	0.57	36.4	4	0.086	2.24	1.06	0.60	10	0	0	0	0	0	100	0	0.11		29	60	11
AC15	English Colony Road	0.58	430	475	0.42	0.42	108.0	4	0.099	2.56	0.66	0.60	7	0	0	0	0	0	60	40	0.09			75	25
AC16	Colwell Road	0.54	420	430	0.61	0.38	16.5	4	0.095	2.47	0.96	0.60	8	0	0	0	0	0	70	30	0.09			97	3
AC20	Citrus Colony Road	0.66	365	420	0.57	0.32	96.8	4	0.086	2.24	0.60	0.60	10	0	0	0	0	0	100	0	0.09		2	92	6
AC25	Conf w/Clark Tun. Rd Trib.	0.54	339	365	0.98	0.53	26.4	4	0.111	2.89	1.36	0.60	5	2	0	0	0	8	0	90	0.10		8	84	8
AC30	Delmar Avenue/Loomis	0.94	290	339	1.17	0.72	41.7	3	0.078	2.02	1.03	0.60	6	0	0	0	0	0	50	50	0.10		10	80	10
AC35	Conf w/Clover Val. Cr.	1.02	222	290	1.63	1.10	41.7	3	0.051	1.31	0.86	0.60	24	15	0	30	0	0	0	55	0.12		5	65	30

TABLE 2-5 (Continued)

Basin ID	Basin Description	Basin Area (sq mi)	Chan DElev (ft)	Basin UElev (ft)	Basin Length (mi)	Basin Centrd (mi)	Basin Slope (ft/mi)	Basin Type (Tab2-4)	Basin 'n'	Basin Ct	Basin Lag (hr)	Basin Cp	Imp Area (%)	1989 Land Use Conditions Comm 0.90	HDR 0.60	MDR 0.30	LDR 0.20 (%)	RLDR 0.15	RR/RE 0.10	Open 0.02	Loss Rates (in/hr)	SCS Soil Classification A:.48 A:.31	B:.25 B:.18	C:.16 C:.09	D:.12 D:.07
AC40	Sunset Blvd	1.27	200	240	1.44	0.61	27.8	3	0.043	1.12	0.62	0.60	40	20	20	30	0	0	0	30	0.11		5		95
AC41	Rocklin City Boundary	0.75	200	205	0.98	0.66	5.1	3	0.042	1.09	0.73	0.61	42	15	30	35	0	0	0	20	0.12		8	2	90
AC45	Mouth of Antelope Cr.	0.77	140	200	2.20	1.29	27.3	3	0.060	1.57	1.28	0.60	13	8	5	5	0	0	0	82	0.09		8		92
CV1	English Colony Road	1.18	515	635	0.95	0.95	126.7	4	0.151	3.92	1.70	0.60	2	0	0	0	0	0	0	100	0.08			35	65
CV5	Wood Glen Drive	0.95	370	515	2.01	0.87	72.2	4	0.151	3.92	2.33	0.60	2	0	0	0	0	0	0	100	0.08		8	17	75
CV6	Creekwood Drive	0.95	270	370	1.97	1.14	50.8	4	0.121	3.14	2.14	0.60	4	0	0	0	10	0	0	90	0.09		13	29	58
CV10	Mouth of Clover Valley	0.54	222	270	1.25	0.98	38.4	3	0.063	1.64	0.96	0.60	12	0	0	25	15	0	0	60	0.10		8	2	90
DC4	Parry Street	0.67	130	140	0.76	0.42	13.2	3	0.039	1.03	0.46	0.66	52	30	40	0	0	0	0	30	0.13		15	15	70
DC5	Conf. with Cirby Cr.	0.60	120	130	1.17	0.80	8.5	3	0.039	1.00	0.69	0.68	56	35	35	10	0	0	0	20	0.14		24		76
DC10	Vernon Avenue	0.72	115	160	0.95	0.19	47.5	2	0.030	0.79	0.24	0.62	44	15	20	60	0	0	0	5	0.14		15		85
DC15	SPRR Bridge	0.89	114	160	1.52	0.76	30.4	2	0.030	0.79	0.47	0.62	44	25	15	40	0	0	0	20	0.11				100
DC20	Conf. with DC25/DC80 Tribs.	1.15	96	160	2.35	1.17	27.3	2	0.030	0.79	0.64	0.62	44	40	5	0	0	30	0	25	0.12		25		75
DC25	Dry Creek DC25 Trib.	1.71	96	150	2.23	1.59	24.2	2	0.035	0.91	0.82	0.60	28	10	10	25	0	35	0	20	0.14		40		60
DC35	Cook Riolo Road	0.36	89	96	0.38	0.17	18.5	3	0.070	1.81	0.45	0.60	9	0	0	0	0	50	0	50	0.09		25		75
DC40	Dry Creek DC40 Trib.	0.37	86	140	0.93	0.57	58.2	2	0.049	1.27	0.52	0.60	10	0	0	0	0	60	0	40	0.08		10		90
DC45	Conf. with DC40 Trib.	0.27	86	89	0.38	0.27	7.9	3	0.068	1.77	0.59	0.60	9	0	0	0	0	55	0	45	0.12		50		50
DC50	Conf. with DC55 Trib.	0.46	79	86	0.76	0.61	9.2	3	0.081	2.11	1.13	0.60	5	0	0	0	0	25	0	75	0.12		60		40
DC55	Dry Creek DC55 Trib.	0.69	80	130	1.10	0.64	45.5	3	0.070	1.82	0.86	0.60	8	0	3	5	0	25	0	67	0.08		10		90
DC60	Conf. with DC65 Trib.	0.87	72	79	1.46	0.57	4.8	3	0.073	1.91	1.39	0.60	7	0	8	2	0	0	0	90	0.11		35		65
DC65	Dry Creek DC65 Trib.	1.28	72	120	2.01	1.42	23.9	3	0.071	1.86	1.56	0.60	8	0	0	0	0	45	0	55	0.09	0	20	0	80
DC68	Cty Line Trib. at PFE Road	1.35	90	155	2.73	1.40	23.8	3	0.076	1.97	1.81	0.60	7	0	0	7	0	20	0	73	0.07				100
DC70	Cty Line Trib. at Watt Ave.	0.44	74	90	0.95	0.76	16.9	3	0.110	2.86	1.61	0.60	2	0	0	0	0	0	0	100	0.09		25	0	75
DC71	Mouth of Cty Line Trib.	0.27	69	100	0.66	0.38	46.8	3	0.075	1.95	0.66	0.60	7	2	0	2	0	0	30	66	0.09		15		85
DC75	Watt Avenue	0.68	70	150	1.14	0.64	70.4	3	0.110	2.86	1.28	0.60	2	0	0	0	0	0	0	100	0.11		40		60
DC76	Conf with Cty Line Trib.	0.42	69	110	0.83	0.47	49.2	3	0.092	2.39	0.92	0.60	4	0	0	0	5	5	0	90	0.10		30	0	70
DC80	Cook Riolo Road	1.97	96	157	2.41	1.14	25.4	2	0.031	0.80	0.66	0.61	42	36	0	0	0	64	0	0	0.09		5		95
DC85	Conf. with DC90 Trib.	0.32	64	69	0.80	0.53	6.3	3	0.072	1.86	1.03	0.60	8	5	0	5	0	0	0	90	0.13		60		40
DC90	Dry Creek DC90 Trib.	0.69	64	97	1.55	1.14	21.2	3	0.054	1.41	1.03	0.60	19	5	7	30	0	0	0	58	0.10		5		95
DC95	Sierra Cr. at Walerga Rd	0.91	105	150	1.33	0.72	33.9	3	0.047	1.23	0.68	0.60	29	5	5	70	0	0	0	20	0.11				100
DC96	Sierra Cr. at Watt Ave.	1.45	73	150	1.70	0.64	45.2	3	0.068	1.78	0.98	0.60	9	0	0	25	0	0	0	75	0.08				100
DC100	Mouth of Sierra Creek	0.54	63	73	1.33	0.64	7.5	3	0.053	1.37	0.93	0.60	21	5	10	25	0	10	0	50	0.09				100
DC105	Dry Creek DC105 Trib.	1.06	54	89	1.70	0.98	20.5	3	0.055	1.44	1.04	0.60	18	5	0	40	0	0	0	55	0.09				100
DC110	Conf with Sierra Creek	0.26	63	85	0.76	0.11	29.0	3	0.057	1.48	0.38	0.60	16	0	0	50	0	0	0	50	0.14		40		60
DC115	Conf with DC105 Trib.	0.32	54	63	0.42	0.23	21.6	3	0.056	1.46	0.40	0.60	17	0	0	40	0	28	0	32	0.13		35		65
DC120	Q Street	0.53	52	75	0.66	0.38	34.7	3	0.064	1.65	0.58	0.60	11	0	0	0	0	72	0	28	0.13				
DC125	Elkhorn Blvd	1.37	45	52	1.59	0.98	4.4	3	0.062	1.60	1.45	0.60	13	0	0	0	30	40	0	30	0.12		35		65
DC130	Rio Linda Blvd	0.91	37	45	1.17	0.83	6.8	3	0.057	1.47	1.07	0.60	16	5	0	20	10	20	0	45	0.14		55		45
DC135	Natomas E Main Drain	1.04	27	37	1.67	1.25	6.0	3	0.066	1.72	1.63	0.60	10	0	0	5	15	30	0	50	0.11		30	5	65

TABLE 2-6

FUTURE CONDITION SUBBASIN HYDROLOGIC DATA

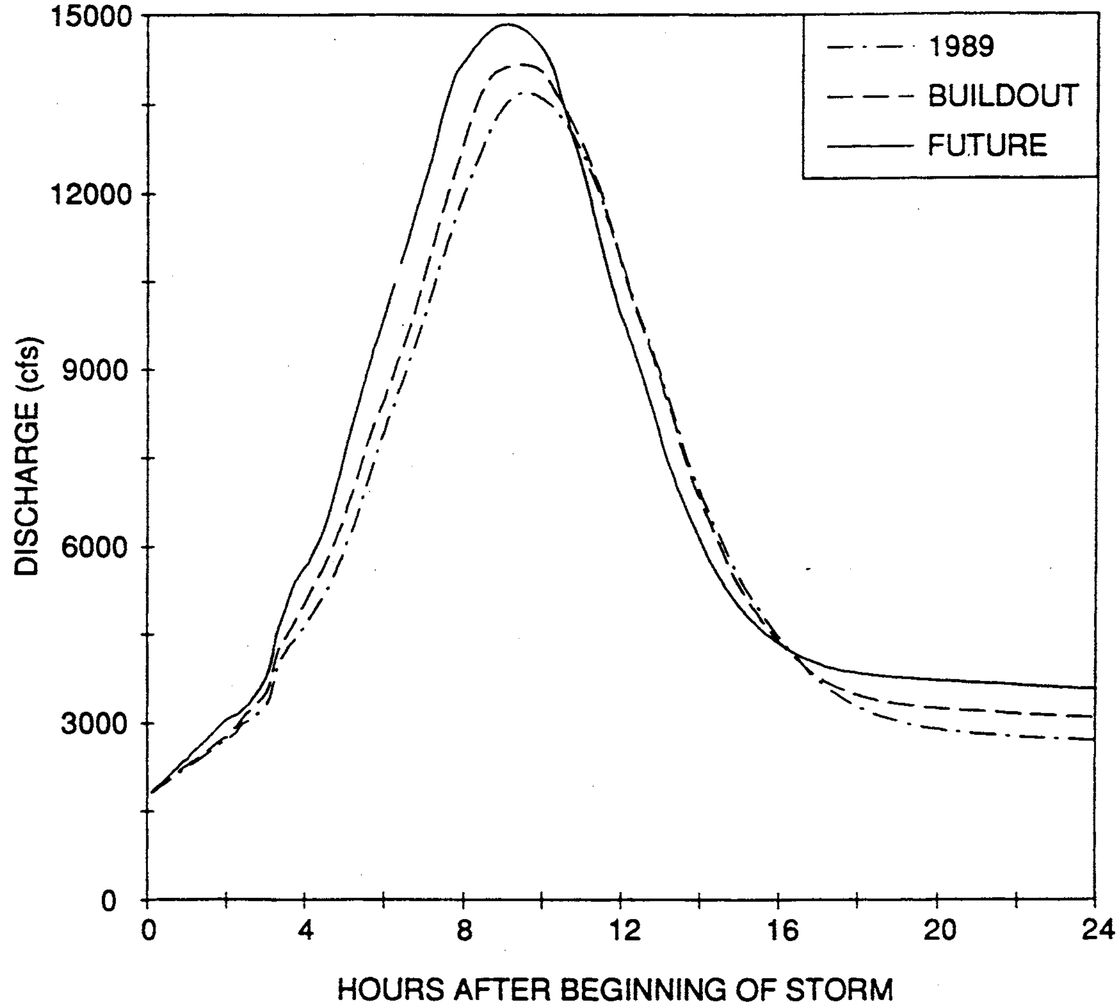
Basin ID	Basin Description	Basin Area (sq mi)	Chan DElev (ft)	Basin UElev (ft)	Basin Length (mi)	Basin Centrd (mi)	Basin Slope (ft/mi)	Basin Type (Tab2-4)	Basin 'n'	Basin Ct	Basin Lag (hr)	Basin Cp	Imp Area (%)	General Plan Land Use Conditions (%): Comm 0.90	HDR 0.60	MDR 0.30	LDR 0.20	RLDR 0.15	RR/RE 0.10	Open 0.02	Loss Rates (in/hr)	Soil Classification: A:.48 A:.31	B:.25 B:.16	C:.16 C:.09	D:.12 D:.07
LC1	Auburn-Folsom Road	0.57	380	460	1.14	0.64	70.4	2	0.034	0.88	0.39	0.60	32	7	2	66	12	13	0	0	0.14			75	25
LC5	Barton Road	0.95	320	380	1.10	0.53	54.6	3	0.057	1.49	0.65	0.60	16	2	2	0	2	80	0	14	0.09			65	35
LC10	Wedgewood Drive	0.25	300	320	0.64	0.19	31.1	3	0.059	1.53	0.43	0.60	15	0	0	0	0	90	10	0	0.07			15	85
LC15	Cherry Avenue	1.55	230	300	1.36	0.76	51.3	3	0.056	1.45	0.76	0.60	17	0	0	20	22	44	0	14	0.13		40		60
LC20	Walnut Avenue	0.45	220	260	0.76	0.57	52.8	2	0.036	0.95	0.37	0.60	25	0	0	65	0	35	0	0	0.17		55		45
LC25	Walnut Avenue	0.41	220	330	0.91	0.76	121.0	3	0.054	1.40	0.56	0.60	20	0	0	30	0	70	0	0	0.10		10		90
LC30	Oak Avenue	0.32	195	220	1.17	0.76	21.3	3	0.064	1.67	0.97	0.60	11	0	0	0	0	70	0	30	0.13		70		30
LC35	Oak Avenue	1.12	210	251	1.29	0.49	31.8	2	0.038	0.99	0.48	0.60	22	0	0	45	0	55	0	0	0.13		35		65
LC40	Hazel Avenue	0.87	195	230	1.48	1.14	23.7	3	0.060	1.56	1.10	0.60	14	0	0	0	0	90	0	10	0.12		50		50
LC45	Indian Creek Drive	1.18	170	220	1.44	0.49	34.7	3	0.060	1.56	0.77	0.60	14	0	0	5	0	80	0	15	0.08		5		95
LC50	Treelake Road	0.84	240	345	1.29	0.85	81.5	3	0.059	1.55	0.77	0.60	14	0	0	0	32	18	50	0	0.10			35	65
LC55	Sierra College Blvd	0.89	197	240	0.98	0.61	43.7	2	0.036	0.94	0.43	0.60	25	1	0	47	43	9	0	0	0.14		15	5	80
LC60	Linda Creek	0.30	168	197	1.17	0.68	24.7	3	0.059	1.54	0.84	0.60	14	0	0	0	0	85	15	0	0.09		20		80
LC65	Country Lake Drive	0.43	180	220	0.72	0.53	55.6	3	0.057	1.49	0.56	0.60	16	0	0	5	0	95	0	0	0.11		45		55
LC70	Old Auburn Road	0.18	168	170	0.59	0.30	3.4	3	0.058	1.52	0.70	0.60	15	0	0	0	0	100	0	0	0.07				100
LC80	Champion Oaks Drive	0.98	149	230	1.29	0.19	62.9	2	0.034	0.89	0.28	0.60	31	3	9	62	2	24	0	0	0.13		15		85
LC82	Strap Ravine	0.09	141	149	0.27	0.15	30.2	2	0.032	0.82	0.16	0.60	39	0	43	43	0	0	0	14	0.14		25		75
LC85	Rocky Ridge Drive	0.26	140	141	0.57	0.08	1.8	2	0.032	0.83	0.27	0.60	38	0	40	45	0	0	0	15	0.14		20		80
LC90	Oak Ridge Drive	0.46	133	140	0.95	0.57	7.4	2	0.032	0.84	0.49	0.60	37	0	50	20	0	0	0	30	0.14		30		70
LC95	Cirby Creek	0.16	130	133	0.42	0.23	7.2	1	0.017	0.45	0.15	0.75	69	50	40	0	0	0	0	10	0.17		40		60
CC1	Douglas Boulevard	0.38	230	260	0.87	0.38	34.4	2	0.029	0.76	0.30	0.65	49	27	32	0	17	0	24	0	0.11			5	95
CC2	Douglas Boulevard	0.25	195	220	0.49	0.38	50.8	1	0.016	0.42	0.13	0.81	83	75	25	0	0	0	0	0	0.07				100
CC5	East Roseville Parkway	0.20	195	270	0.27	0.27	282.9	1	0.018	0.46	0.08	0.71	61	47	31	0	0	0	0	22	0.13		15		85
CC10	Huntington Drive	0.24	151	190	0.42	0.08	93.6	2	0.032	0.84	0.13	0.60	36	10	15	60	0	0	0	15	0.16		35		65
CC15	Sierra Gardens Drive	0.15	150	151	0.21	0.09	4.8	1	0.018	0.47	0.10	0.69	57	10	80	0	0	0	0	10	0.13		15		85
CC20	Douglas Boulevard	0.38	151	230	0.95	0.25	83.4	1	0.016	0.41	0.12	0.85	89	98	2	0	0	0	0	0	0.13		5		95
CC25	Sierra Gardens Drive	0.05	150	151	0.27	0.15	3.8	1	0.018	0.47	0.13	0.68	56	35	40	0	0	0	0	25	0.12		5	20	75
CC30	Loretto Drive	0.15	148	150	0.27	0.27	7.5	1	0.017	0.44	0.13	0.75	71	60	20	15	0	0	0	5	0.16		35	5	60
CC35	Oak Ridge Drive	0.13	140	148	0.42	0.17	19.2	1	0.019	0.50	0.13	0.64	48	20	40	20	0	0	0	20	0.13		20		80
CC40	Linda Creek	0.16	130	140	0.53	0.23	18.9	1	0.017	0.45	0.14	0.73	66	40	50	0	0	0	0	10	0.15		25		75
CC45	Dry Creek	1.12	120	160	1.17	0.59	34.1	1	0.019	0.51	0.25	0.63	46	15	42	20	3	0	0	20	0.12		10		90
SR1	Barton Road	1.16	320	420	1.74	0.38	57.4	2	0.036	0.95	0.42	0.60	25	9	3	6	42	14	26	0	0.13			85	15
SR5	Sierra College Blvd	1.77	215	350	2.08	0.95	64.8	3	0.055	1.44	0.90	0.60	18	5	0	10	10	15	60	0	0.11	5	5	20	70
SR8	East Roseville Parkway	0.19	200	215	0.42	0.23	36.0	2	0.031	0.81	0.21	0.61	41	0	58	20	0	0	0	22	0.11				100
SR10	East Roseville Parkway	0.45	200	230	0.95	0.61	31.7	1	0.019	0.49	0.23	0.65	50	44	4	0	35	0	5	12	0.11				100
SR15	Eureka Road	0.17	190	200	0.38	0.30	26.4	2	0.032	0.84	0.24	0.60	37	0	45	30	0	0	0	25	0.11				100
SR20	McLaren Drive	0.28	150	190	0.72	0.38	55.6	2	0.031	0.79	0.27	0.62	44	10	25	65	0	0	0	0	0.15		20		80
SR25	Linda Creek	0.05	141	150	0.19	0.09	47.5	2	0.034	0.89	0.13	0.60	30	0	0	100	0	0	0	0	0.18		45		55
MR1	Rock Springs Road	0.50	740	830	0.72	0.42	125.1	3	0.066	1.72	0.52	0.60	10	0	0	0	0	0	100	0	0.13		50	50	
MR5	King Road	1.44	630	740	1.06	0.57	103.7	3	0.066	1.72	0.68	0.60	10	0	0	0	0	0	100	0	0.10		15	85	
MR10	Horseshoe Bar Road	1.05	555	630	0.95	0.61	79.2	3	0.063	1.63	0.66	0.60	12	0	0	0	20	0	80	0	0.10			95	5
MR15	Dick Cook Road	2.12	479	635	1.70	0.80	91.5	3	0.063	1.63	0.85	0.60	12	0	0	0	20	0	80	0	0.10		3	90	7
MR19	Lake Trib.	1.59	418	495	1.67	0.95	46.2	3	0.066	1.72	1.06	0.60	10	0	0	0	0	0	100	0	0.09	0	0	92	8
MR20	Conf. with MR19 Trib.	2.18	418	479	1.89	1.29	32.2	3	0.065	1.70	1.28	0.60	11	0	0	0	0	10	90	0	0.09		3	83	14

TABLE 2-6 (Continued)

Basin ID	Basin Description	Basin Area (sq mi)	Chan DElev (ft)	Basin UElev (ft)	Basin Length (mi)	Basin Centrd (mi)	Basin Slope (ft/mi)	Basin Type (Tab2-4)	Basin 'n'	Basin Ct	Basin Lag (hr)	Basin Cp	Imp Area (%)	General Plan Land Use Conditions (%): Comm 0.90	HDR 0.60	MDR 0.30	LDR 0.20	RLDR 0.15	RR/RE 0.10	Open 0.02	Loss Rates (in/hr)	Soil Classification: A:.48 A:.31	B:.25 B:.16	C:.16 C:.09	D:.12 D:.07
MR21	Cavitt Stallman Road	1.39	380	418	0.72	0.38	52.8	3	0.064	1.65	0.56	0.60	11	0	0	0	0	35	60	5	0.09			96	4
MR24	Barton Road	1.23	380	475	1.40	0.83	67.8	3	0.066	1.72	0.90	0.60	10	0	0	0	0	0	100	0	0.09		3	93	4
MR25	Sierra College Blvd	1.39	240	380	2.08	1.17	67.2	3	0.066	1.71	1.15	0.60	10	0	0	1	0	0	99	0	0.09		4	56	40
MR29	Auburn-Folsom Road	1.26	370	450	1.25	0.21	64.0	3	0.061	1.58	0.51	0.60	13	0	0	10	10	50	0	30	0.10			94	6
MR30	Barton Road	1.75	310	420	2.46	1.33	44.7	3	0.064	1.66	1.31	0.60	11	0	0	0	8	15	72	5	0.09			94	6
MR31	Sierra College Blvd	1.70	240	345	2.08	0.89	50.4	3	0.058	1.52	0.97	0.60	15	0	1	5	14	40	40	0	0.09			60	40
MR35	Boardman Trib.	1.00	182	438	2.31	1.17	110.8	3	0.056	1.45	0.93	0.60	17	0	0	20	35	0	41	4	0.10				100
MR36	Conf. w/Boardman Trib.	0.71	182	240	1.89	1.14	30.6	2	0.039	1.00	0.73	0.60	21	5	5	0	45	0	40	5	0.10		6	0	94
MR37	Conf. with Secret Rav.	0.16	160	182	0.68	0.42	32.3	2	0.030	0.79	0.29	0.62	44	28	22	0	24	0	0	26	0.14		28	0	72
MR40	Mouth of Miners Ravine	0.38	140	160	0.61	0.34	33.0	1	0.016	0.42	0.14	0.84	87	90	10	0	0	0	0	0	0.18	10	20		70
SE1	Gilardi Road	1.54	540	730	1.27	0.72	149.7	3	0.062	1.61	0.68	0.60	12	3	0	0	0	0	97	0	0.07			5	95
SE5	E. Fk Penryn at Sec. R.	0.57	495	700	1.17	0.85	174.6	3	0.061	1.58	0.67	0.60	13	2	3	0	0	0	95	0	0.09		10	20	70
SE7	Rock Springs Road	0.40	470	495	0.27	0.19	94.3	3	0.066	1.72	0.30	0.60	10	0	0	0	0	0	100	0	0.10		19	57	24
SE10	Conf. w/E. Fk Penryn Trib.	0.49	495	540	0.57	0.28	79.2	3	0.066	1.71	0.46	0.60	10	0	0	0	2	0	98	0	0.09		5	50	45
SE15	Boulder Creek Road	0.74	400	470	0.83	0.57	84.0	3	0.056	1.47	0.55	0.60	17	8	0	0	2	0	90	0	0.11	6	9	65	20
SE20	Newcastle Road	2.03	760	1200	1.52	0.91	290.4	3	0.058	1.51	0.66	0.60	15	4	2	2	6	0	86	0	0.13		45	25	30
SE25	Brennans Road	0.84	640	760	1.25	0.45	96.0	3	0.066	1.72	0.67	0.60	10	0	0	0	0	0	100	0	0.11		24	71	5
SE26	Boulder Creek Road	0.70	400	640	1.59	0.76	150.9	3	0.066	1.72	0.80	0.60	10	0	0	0	0	0	100	0	0.09		8	74	18
SE30	King Road	0.67	378	400	0.80	0.42	27.7	3	0.058	1.50	0.60	0.60	16	5	0	0	15	0	80	0	0.11		10	70	20
SE35	Conf. with King Rd. Trib.	0.34	352	378	0.76	0.42	34.3	3	0.054	1.40	0.53	0.60	20	9	3	4	0	0	84	0	0.09			55	45
SE40	Horseshoe Bar Road	1.14	351	440	1.59	1.52	55.9	2	0.035	0.91	0.63	0.60	28	18	2	12	0	0	68	0	0.11		3	76	21
SE44	King R. Trib. at Val Verde R.	0.90	438	680	1.52	0.95	159.7	3	0.066	1.72	0.84	0.60	10	0	0	0	0	0	100	0	0.10		17	70	13
SE45	King Rd. Trib. at Secret Rav.	2.27	352	438	1.14	1.14	75.7	3	0.066	1.72	0.92	0.60	10	0	0	0	0	0	100	0	0.09		7	83	10
SE50	Loomis City Boundary	1.83	319	351	0.91	0.45	35.2	3	0.061	1.59	0.66	0.60	13	0	0	10	8	0	82	0	0.10		1	82	17
SE51	Sierra College Blvd	1.03	280	319	0.76	0.38	51.5	3	0.058	1.51	0.52	0.60	15	0	0	29	11	0	40	20	0.12		5	84	11
SE52	Rocklin Road	0.47	260	280	1.29	0.76	15.5	2	0.032	0.83	0.52	0.60	37	20	5	50	5	0	0	20	0.18	3	50	3	44
SE55	Aguilar Trib., Sierra Coll. Bd.	1.11	300	355	1.40	1.14	39.2	3	0.055	1.43	0.91	0.60	18	0	5	28	0	0	67	0	0.12		8	77	15
SE56	Aguilar Trib. at Sec. Rav.	0.73	260	300	0.91	0.42	44.0	2	0.034	0.88	0.34	0.60	32	0	14	68	2	16	0	0	0.15		2	89	9
SE57	Conf. with Sucker Ravine	0.19	215	250	0.53	0.30	66.0	2	0.036	0.93	0.26	0.60	26	0	13	38	33	0	0	16	0.10			68	32
SE60	Sucker R./E. Trib., Sucker R.	0.66	280	350	1.67	1.06	42.0	1	0.019	0.49	0.32	0.66	52	45	0	35	0	0	5	15	0.16		12	88	
SE65	Sucker Rav. at King Rd.	0.34	350	415	0.76	0.23	85.8	1	0.019	0.50	0.13	0.64	48	30	0	65	5	0	0	0	0.15		0	72	28
SE68	Sucker R. at Conf. w/E. Trib.	0.97	280	340	1.93	1.33	31.1	2	0.035	0.91	0.70	0.60	28	15	0	24	23	0	30	8	0.14		3	96	1
SE70	Sucker R. at Rocklin Rd	0.70	260	280	1.14	0.76	17.6	1	0.018	0.47	0.28	0.70	59	52	3	35	0	0	0	10	0.16	8	10	22	60
SE76	Sucker Ravine at I-80	0.22	215	260	0.64	0.34	69.9	2	0.033	0.85	0.26	0.60	35	5	10	80	0	0	5	0	0.13		0	20	80
SE80	Rocklin City Boundary	0.81	180	215	1.21	0.57	28.9	2	0.035	0.91	0.46	0.60	28	5	6	45	32	0	0	12	0.13		10	5	85
SE85	Mouth of Secret Ravine	0.72	160	180	1.14	0.91	17.6	3	0.057	1.49	0.94	0.60	16	7	0	5	35	0	0	53	0.11	3	7		90
AC1	CTR Trib. at Cl. Tun. Rd	0.64	550	698	0.76	0.45	195.4	3	0.066	1.71	0.50	0.60	10	0	0	0	3	0	97	0	0.07			12	88
AC2	CTR Trib. at English Col.	1.20	490	550	1.06	0.53	56.6	3	0.061	1.58	0.67	0.60	13	3	0	0	4	0	96	0	0.08	0	0	16	84
AC4	CTR Trib. at Colwell Rd	0.45	445	490	0.57	0.38	79.2	3	0.058	1.52	0.44	0.60	15	5	0	0	10	0	85	0	0.10		12	63	25
AC5	CTR Trib. Conf. w/Humphrey	1.61	379	575	1.70	0.83	115.0	3	0.060	1.57	0.80	0.60	14	3	2	0	5	0	85	5	0.11		15	80	5
AC10	CTR Trib. Conf. w/Antel. Cr.	0.30	339	379	1.10	0.57	36.4	3	0.061	1.60	0.76	0.60	13	0	4	0	7	0	89	0	0.12		29	60	11
AC15	English Colony Road	0.58	430	475	0.42	0.42	108.0	3	0.066	1.72	0.45	0.60	10	0	0	0	0	0	100	0	0.09			75	25
AC16	Colwell Road	0.54	420	430	0.61	0.38	16.5	3	0.070	1.82	0.70	0.60	8	0	0	0	0	0	80	20	0.09			97	3
AC20	Citrus Colony Road	0.66	365	420	0.57	0.32	96.8	3	0.066	1.72	0.46	0.60	10	0	0	0	0	0	100	0	0.09		2	92	6
AC25	Conf w/Clark Tun. Rd Trib.	0.54	339	365	0.98	0.53	26.4	3	0.062	1.61	0.76	0.60	12	2	0	0	8	0	90	0	0.10		8	84	8
AC30	Delmar Avenue/Loomis	0.94	290	339	1.17	0.72	41.7	3	0.062	1.62	0.83	0.60	12	0	0	5	11	0	84	0	0.11		10	80	10
AC35	Conf w/Clover Val. Cr.	1.02	222	290	1.63	1.10	41.7	2	0.035	0.91	0.60	0.60	28	15	0	32	13	0	21	19	0.13		5	65	30

TABLE 2-6 (Continued)

Basin ID	Basin Description	Basin Area (sq mi)	Chan DElev (ft)	Basin UElev (ft)	Basin Length (mi)	Basin Centrd (mi)	Basin Slope (ft/mi)	Basin Type (Tab2-4)	Basin 'n'	Basin Ct	Basin Lag (hr)	Basin Cp	Imp Area (%)	General Plan Land Use Conditions (%) Comm 0.90	HDR 0.60	MDR 0.30	LDR 0.20	RLDR 0.15	RR/RE 0.10	Open 0.02	Loss Rates (in/hr)	Soil Classification A:.48 A:.31	B:.25 B:.16	C:.16 C:.09	D:.12 D:.07
AC40	Sunset Blvd	1.27	200	240	1.44	0.61	27.8	2	0.031	0.80	0.44	0.61	42	20	20	40	0	0	0	20	0.12		5		95
AC41	Rocklin City Boundary	0.75	200	205	0.98	0.66	5.1	2	0.030	0.78	0.52	0.63	45	15	30	45	0	0	0	10	0.13		8	2	90
AC45	Mouth of Antelope Cr.	0.77	140	200	2.20	1.29	27.3	2	0.035	0.91	0.74	0.60	28	13	7	25	19	0	0	36	0.11		8		92
CV1	English Colony Road	1.18	515	635	0.95	0.95	126.7	3	0.110	2.86	1.24	0.60	2	0	0	0	0	0	0	100	0.08			35	65
CV5	Wood Glen Drive	0.95	370	515	2.01	0.87	72.2	3	0.110	2.86	1.70	0.60	2	0	0	0	0	0	0	100	0.08		8	17	75
CV6	Creekwood Drive	0.95	270	370	1.97	1.14	50.8	3	0.065	1.69	1.16	0.60	11	0	0	0	47	0	1	52	0.12		13	29	58
CV10	Mouth of Clover Valley	0.54	222	270	1.25	0.98	38.4	3	0.054	1.41	0.83	0.60	19	0	0	37	36	0	0	27	0.12		8	2	90
DC4	Parry Street	0.67	130	140	0.76	0.42	13.2	1	0.017	0.45	0.20	0.73	66	45	40	0	5	0	0	10	0.14		24		76
DC5	Conf. with Cirby Cr.	0.60	120	130	1.17	0.80	8.5	1	0.017	0.45	0.31	0.74	68	35	55	10	0	0	0	0	0.15		15	15	70
DC10	Vernon Avenue	0.72	115	160	0.95	0.19	47.5	2	0.030	0.77	0.23	0.64	48	20	20	60	0	0	0	0	0.14		15		85
DC15	SPRR Bridge	0.89	114	160	1.52	0.76	30.4	1	0.018	0.48	0.28	0.68	55	34	17	45	4	0	0	0	0.12				100
DC20	Conf. with DC25/DC80 Tribs.	1.15	96	160	2.35	1.17	27.3	1	0.018	0.47	0.38	0.69	59	55	5	0	0	40	0	0	0.13		25		75
DC25	Dry Creek DC25 Trib.	1.71	96	150	2.23	1.59	24.2	2	0.032	0.82	0.74	0.60	39	20	10	25	5	40	0	0	0.15		40		60
DC35	Cook Riolo Road	0.36	89	96	0.38	0.17	18.5	3	0.058	1.52	0.38	0.60	15	0	0	0	0	100	0	0	0.09		25		75
DC40	Dry Creek DC40 Trib.	0.37	86	140	0.93	0.57	58.2	2	0.041	1.06	0.44	0.60	17	0	0	14	0	86	0	0	0.09		10		90
DC45	Conf. with DC40 Trib.	0.27	86	89	0.38	0.27	7.9	3	0.058	1.52	0.50	0.60	15	0	0	0	0	100	0	0	0.12		50		50
DC50	Conf. with DC55 Trib.	0.46	79	86	0.76	0.61	9.2	3	0.060	1.57	0.84	0.60	13	0	0	0	0	88	0	12	0.12		60		40
DC55	Dry Creek DC55 Trib.	0.69	80	130	1.10	0.64	45.5	2	0.036	0.93	0.44	0.60	27	7	5	29	5	50	0	4	0.10		10		90
DC60	Conf. with DC65 Trib.	0.87	72	79	1.46	0.57	4.8	2	0.039	1.00	0.73	0.60	21	5	8	3	26	32	0	26	0.13		35		65
DC65	Dry Creek DC65 Trib.	1.28	72	120	2.01	1.42	23.9	3	0.062	1.62	1.36	0.60	12	0	0	0	14	58	0	28	0.10		20	0	80
DC68	Cty Line Trib. at PFE Road	1.35	90	155	2.73	1.40	23.8	2	0.036	0.93	0.85	0.60	27	1	2	70	2	20	0	5	0.11				100
DC70	Cty Line Trib. at Watt Ave.	0.44	74	90	0.95	0.76	16.9	3	0.053	1.39	0.78	0.60	20	0	0	35	45	0	0	20	0.14		25	0	75
DC71	Mouth of Cty Line Trib.	0.27	69	100	0.66	0.38	46.8	2	0.035	0.92	0.31	0.60	27	10	0	40	12	0	35	3	0.12		15		85
DC75	Watt Avenue	0.68	70	150	1.14	0.64	70.4	3	0.069	1.79	0.80	0.60	9	0	0	0	20	0	40	40	0.12		40		60
DC76	Conf with Cty Line Trib.	0.42	69	110	0.83	0.47	49.2	3	0.072	1.87	0.72	0.60	8	0	0	0	5	15	35	45	0.10		30	0	70
DC80	Cook Riolo Road	1.97	96	157	2.41	1.14	25.4	1	0.019	0.49	0.40	0.65	50	46	0	0	0	54	0	0	0.10		5		95
DC85	Conf. with DC90 Trib.	0.32	64	69	0.80	0.53	6.3	3	0.061	1.59	0.88	0.60	13	5	0	12	0	24	0	59	0.14		60		40
DC90	Dry Creek DC90 Trib.	0.69	64	97	1.55	1.14	21.2	2	0.033	0.87	0.63	0.60	33	8	7	64	0	13	0	8	0.12		5		95
DC95	Sierra Cr. at Walerga Rd	0.91	105	150	1.33	0.72	33.9	2	0.033	0.86	0.48	0.60	33	5	5	85	0	0	0	5	0.12				100
DC96	Sierra Cr. at Watt Ave.	1.45	73	150	1.70	0.64	45.2	2	0.038	1.00	0.55	0.60	21	1	12	40	0	0	0	47	0.10				100
DC100	Mouth of Sierra Creek	0.54	63	73	1.33	0.64	7.5	2	0.035	0.91	0.62	0.60	28	5	10	40	0	35	0	10	0.10				100
DC105	Dry Creek DC105 Trib.	1.06	54	89	1.70	0.98	20.5	3	0.054	1.39	1.00	0.60	20	5	0	40	0	15	0	40	0.09				100
DC110	Conf with Sierra Creek	0.26	63	85	0.76	0.11	29.0	3	0.057	1.48	0.38	0.60	16	0	0	50	0	0	0	50	0.14		40		60
DC115	Conf with DC105 Trib.	0.32	54	63	0.42	0.23	21.6	3	0.056	1.46	0.40	0.60	17	0	0	40	0	28	0	32	0.13		35		65
DC120	Q Street	0.53	52	75	0.66	0.38	34.7	3	0.064	1.65	0.58	0.60	11	0	0	0	0	72	0	28	0.13				
DC125	Elkhorn Blvd	1.37	45	52	1.59	0.98	4.4	3	0.057	1.49	1.35	0.60	16	0	0	12	30	40	0	18	0.13		35		65
DC130	Rio Linda Blvd	0.91	37	45	1.17	0.83	6.8	3	0.054	1.40	1.01	0.60	19	5	0	30	10	20	0	35	0.15		55		45
DC135	Natomas E Main Drain	1.04	27	37	1.67	1.25	6.0	3	0.066	1.72	1.63	0.60	10	0	0	5	15	30	0	50	0.11		30	5	65
	TOTALS	101											22%												



COMPARISON HYDROGRAPHS, 1989, BUILDOUT, AND FUTURE LAND USE
FIGURE 2-7

500-year storms at the Vernon Street gage are shown in Figure 2-8. In addition to the tabulation of peak flows, at stream crossings and other locations in the watershed, found in Table 2-7, Table 2-8 contains a listing of the maximum flows, by subbasin, for the 2-, 10-, 25-, 100-, and 500-year storms centered over each subbasin.

USE OF MODEL

The HEC-1 model input for the Dry Creek Watershed has been set up with the goal of providing a tool for use in the future. Because of the storm centering method that was used to determine the precipitation for input into the HEC-1 model, there are a large number of input data files. Each of these input files represents the storm centering for a particular HEC-1 flow combination point. Because the file name for each of input file includes the name of the combination point, Table 2-9 indicates the location and names of each of the combination points used in the model. The combination points are described in the table based on the subbasins in which they are located.

When runoff based on changed hydrologic parameters is wanted at a particular combination point in the watershed, it is necessary to modify the input file for that combination point and then run HEC-1 using the input file. Output from the HEC-1 model is then used as input to the FIXFORM program to change the formatting to be more easily readable.

Several Fortran programs were developed as a part of this study to automate the modification of large numbers of input files, and to extract the wanted peak flows from the HEC-1 output files. The input modification program called MODSUB takes data from the hydrologic spreadsheet and inserts it into specified HEC-1 input files. CROSFLOW takes the output from specified HEC-1 output files and combines and interpolates it into flow output tables like Table 2-7. This combination and interpolation of flows, at points between combination points in the model, takes into account not only the magnitude of flows at each of the locations, but also the timing of the flood peaks being combined.

TABLE 2-7

PEAK FLOWS

No.	Distance From Mouth (ft)	Location Description	500-Year 1989 (cfs)	500-Year Future (cfs)	200-Year 1989 (cfs)	200-Year Future (cfs)	100-Year 1989 (cfs)	100-Year Future (cfs)	25-Year 1989 (cfs)	25-Year Future (cfs)	10-Year 1989 (cfs)	10-Year Future (cfs)	2-Year 1989 (cfs)	2-Year Future (cfs)
	DRY CREEK													
1	8900	Rio Linda Blvd (North & Sout	21352	23398	17480	19209	14182	15642	9382	10376	6085	6915	2715	3000
2	15000	Elkhorn Blvd (North & South)	21349	23395	17479	19205	14183	15637	9386	10374	6126	6920	2758	3040
3	16600	Curved Bridge Road (North)	21334	23380	17467	19193	14173	15626	9380	10367	6131	6916	2765	3046
4	17400	Dry Creek Road (North & Sou	21332	23377	17465	19190	14171	15623	9378	10365	6130	6914	2764	3046
5	24400	Q Street (North & South)	21397	23444	17526	19245	14228	15668	9423	10409	6157	6944	2909	3181
6	34900	Sierra Creek Confluence	21333	23378	17473	19184	14184	15612	9398	10379	6132	6921	2901	3171
7	35200	28th Street (South)	21157	23151	17320	18984	14051	15435	9305	10254	6060	6826	2770	3066
8	35400	Elverta Road	21127	23113	17294	18951	14028	15406	9288	10233	6048	6810	2748	3043
9	36900	Confluence County Line Trib.	21145	23131	17313	18964	14048	15414	9308	10253	6055	6817	2761	3060
11	41400	Watt Avenue	21068	23035	17255	18875	14007	15331	9300	10209	6038	6786	2828	3039
13	47700	Confluence with DC65 Trib	21100	23076	17282	18903	14029	15348	9313	10225	6040	6790	2853	3037
14	50300	Walerga Road	21021	22980	17215	18821	13973	15278	9273	10175	6011	6753	2829	2975
16	58800	Cook Riolo Road	20982	22914	17185	18753	13950	15208	9261	10139	5996	6723	3000	3104
17	67000	S. P. Railroad Spur	20738	22577	16974	18449	13767	14932	9125	9940	5883	6569	3135	3185
18	67400	Atkinson Blvd	20738	22577	16974	18449	13767	14932	9125	9940	5883	6569	3135	3185
20	68900	S.P. Railroad Culverts	20732	22562	16969	18433	13764	14916	9127	9935	5894	6569	3459	3503
21	69900	Vernon Street	20656	22449	16903	18335	13706	14830	9084	9871	5860	6518	3439	3467
22	72600	Riverside Avenue	21221	23099	17227	18823	13825	15181	9147	9925	5868	6536	3980	3980
23	73000	Cirby Creek Confluence	21221	23099	17227	18823	13825	15181	9147	9925	5868	6536	3980	3980
24	73800	Darling Way	15823	17127	12878	13965	10370	11272	6943	7551	4361	4849	2760	2761
25	77000	Douglas Blvd.	15821	17120	12875	13956	10365	11262	6941	7544	4359	4844	2599	2601
26	77500	Royer Park Footbridge	15691	16864	12875	13890	10476	11358	6938	7538	4357	4840	2502	2504
27	79100	Lincoln Street	15690	16860	12873	13886	10474	11354	6937	7536	4356	4839	2454	2456
28	79400	Folsom Road	15675	16876	12869	13891	10479	11349	6948	7525	4429	4926	2438	2440
30	84100	Antelope Cr/Miners Ravine	15918	17148	12972	13996	10462	11312	6938	7501	4425	4913	1378	1675
	DRY CREEK/ELVERTA TRIB.													
31		Confluence with Dry Creek	454	605	395	530	344	467	251	344	187	263	72	113
	DRY CREEK/SIERRA CREEK													
32	0	Confluence with Dry Creek	2066	2552	1801	2245	1575	1984	1121	1421	833	1067	208	273
33	1400	28th Street	2018	2497	1759	2197	1539	1942	1095	1390	813	1043	159	212
34	3700	Scotland Drive	1907	2370	1663	2085	1456	1843	1033	1318	767	988	161	228
35	5400	Delaney Drive	1855	2340	1620	2057	1419	1816	1006	1299	747	974	163	230
36	6800	Watt Avenue	1802	2287	1574	2010	1380	1774	977	1269	726	951	172	229
37	10300	Navaho Way	1079	1346	945	1181	831	1041	568	718	452	575	111	141
38	11400	Elverta Road	924	1145	811	1004	714	884	481	600	393	495	98	122
39	13500	Walerga Road	769	943	676	826	596	727	438	537	334	414	141	180

TABLE 2-7 (Continued)

No.	Distance From Mouth (ft)	Location Description	500-Year 1989 (cfs)	500-Year Future (cfs)	200-Year 1989 (cfs)	200-Year Future (cfs)	100-Year 1989 (cfs)	100-Year Future (cfs)	25-Year 1989 (cfs)	25-Year Future (cfs)	10-Year 1989 (cfs)	10-Year Future (cfs)	2-Year 1989 (cfs)	2-Year Future (cfs)
	DRY CREEK/COUNTY LINE TRIB.													
40	0	Confluence with Dry Creek	898	1249	775	1105	671	982	346	558	247	421	90	150
41	3200	Watt Avenue	829	1196	722	1069	630	960	346	558	247	421	68	127
42	8200	PFE Road	645	993	551	868	471	762	346	558	247	421	79	174
	DRY CREEK/DC65 TRIB.													
43	0	Confluence with Dry Cr	659	707	565	608	484	524	352	380	253	277	84	97
44	3000	Walerga Road	527	566	451	487	387	419	282	304	202	222	67	78
	CIRBY CREEK													
45	0	Dry Creek Confluence	4392	4887	4248	4739	4126	4613	2617	2853	1930	2148	1362	1367
46	3000	Interstate 80	4371	4866	4228	4718	4106	4592	2602	2838	1920	2138	1350	1355
48	4600	Wanda Lee Court Footbridge	4384	4886	4240	4739	4118	4614	2595	2834	1922	2143	1388	1390
49	6100	Linda Creek Confluence	6542	7178	5230	5793	4113	4614	2581	2822	1957	2174	1405	1406
50	7400	Sunrise Blvd.	1159	1444	961	1257	793	1098	625	774	454	603	325	325
51	8100	Coloma Way	1176	1440	996	1263	842	1113	640	819	456	604	281	281
52	9100	Oak Ridge Drive	1173	1432	1007	1273	866	1138	629	824	466	616	270	270
53	10000	Sierra Gardens Footbridge	1165	1425	1000	1267	860	1132	625	821	463	613	270	270
54	11800	Loretto Drive	1133	1431	981	1271	851	1135	627	838	479	658	291	291
55	12000	Sierra Gardens Trib. Conf.	1175	1440	1009	1275	867	1135	646	854	463	669	134	228
56	12500	Sierra Gardens Drive	929	1247	803	1097	696	969	298	636	231	499	56	121
57	13900	Huntington Drive	895	1271	768	1116	659	984	485	730	346	566	75	165
58	14500	Rocky Ridge Drive	559	742	478	646	409	565	301	416	212	319	46	93
60	16400	Winchester Way	482	670	414	581	356	505	262	370	186	284	40	84
61	17200	Eureka Road	485	745	416	643	357	557	261	407	189	317	40	84
62	19700	Douglas Blvd.	280	568	245	496	215	435	158	325	117	254	41	119
	CIRBY CREEK/SIERRA GARDENS TRIB.													
63	0	Cirby Creek Confluence	208	240	172	203	141	172	109	132	95	107	90	125
65	1000	Douglas Blvd	150	150	148	150	147	150	129	146	108	131	62	90
66	1400	Sierra Gardens Ret. Basin	143	143	141	143	140	143	123	139	103	124	59	86
	LINDA CREEK													
67	0	Cirby Creek Confluence	5990	6592	4900	5443	3972	4464	2538	2751	1816	2022	1133	1136
68	1000	Sunrise Avenue	5987	6587	4898	5439	3970	4461	2537	2749	1815	2021	1132	1134
70	2600	Oak Ridge Drive	6185	6760	5000	5575	3991	4565	3116	3266	2051	2325	1198	1199
72	4300	Sierra Gardens Footbridge	6160	6731	4986	5556	3985	4555	3094	3244	2037	2309	1198	1198
73	8400	Rocky Ridge Drive	6030	6574	5020	5521	4159	4624	3045	3194	2007	2275	1354	1355
74	10000	Strap Ravine Confluence	6024	6531	4983	5455	4097	4538	3004	3153	1982	2246	1214	1214
76	11500	Champion Oaks Drive	4619	4985	3905	4244	3297	3612	2338	2476	1566	1775	361	437
78	14300	Auburn Road	4562	4931	3904	4239	3343	3649	2199	2335	1479	1677	357	429
79	15700	Old Auburn Road/City Limits	4652	5039	3914	4250	3285	3577	2239	2381	1579	1741	356	427

TABLE 2-7 (Continued)

No.	Distance From Mouth (ft)	Location Description	500-Year 1989 (cfs)	500-Year Future (cfs)	200-Year 1989 (cfs)	200-Year Future (cfs)	100-Year 1989 (cfs)	100-Year Future (cfs)	25-Year 1989 (cfs)	25-Year Future (cfs)	10-Year 1989 (cfs)	10-Year Future (cfs)	2-Year 1989 (cfs)	2-Year Future (cfs)
80	15900	Treelake Trib. Confluence	4652	5039	3914	4250	3285	3577	2239	2381	1579	1741	356	427
82	19800	Indian Creek Drive	3474	3832	2942	3261	2489	2774	1716	1839	1172	1329	274	321
83	25300	Hazel Avenue	3213	3519	2677	2950	2220	2465	1505	1696	1034	1201	241	284
84	25500	Orangevale Trib. Confluence	3213	3519	2677	2950	2220	2465	1505	1696	1034	1201	241	284
85	31300	Granite Avenue	1738	1886	1475	1613	1251	1380	775	852	644	730	119	145
86	32600	Cherry Avenue	1703	1841	1448	1576	1230	1351	870	949	623	691	134	163
88	38600	Wedgewood Drive	1186	1357	1025	1181	887	1031	637	738	464	545	111	134
89	42300	East Roseville Parkway	1066	1293	927	1132	809	995	480	539	355	402	102	126
90	43100	Barton Road	1006	1227	874	1074	762	943	470	529	348	395	101	125
91	44600	Shadow Brook Place	848	1036	737	907	642	797	410	463	306	347	86	106
92	46500	Purdy Lane	620	834	541	729	473	640	298	341	227	257	63	84
93	48100	Country Court	510	722	445	631	390	553	244	281	188	213	52	73
94	48700	Auburn Folsom Road	455	666	398	582	349	510	255	377	193	291	79	125
	LINDA	CREEK/STRAP RAVINE												
95	0	Linda Creek Confluence	1339	1494	1110	1254	915	1050	674	766	488	572	133	194
96	1500	McClaren Drive	1335	1490	1111	1255	920	1054	674	767	489	575	132	193
97	5900	Johnson Ranch Drive	1303	1469	1094	1244	916	1053	671	770	487	577	128	186
98	6800	Eureka Road	1299	1468	1092	1244	915	1053	629	721	485	577	127	185
99	8600	East Roseville Parkway	1278	1627	1077	1321	905	1060	664	781	483	587	125	195
100	11800	Sierra College Blvd.	1165	1478	997	1280	854	1112	586	758	426	567	116	158
101	23000	Barton Road	851	1312	744	1154	652	1020	476	751	356	578	135	240
	LINDA	CREEK/TREELAKE TRIB.												
102	0	Linda Creek Confluence	1177	1308	999	1119	847	958	691	766	499	566	356	427
103	3200	Petite Way	1092	1206	931	1034	793	888	625	696	455	515	242	293
104	5700	Old Auburn Road	1075	1314	928	1135	802	982	538	602	395	448	108	140
105	6000	Sierra College Blvd.	1064	1315	920	1137	797	985	521	584	384	435	80	108
106	9600	Swan Lake Drive	766	919	665	800	579	699	376	427	282	320	62	77
107	9600	Swan Lake	766	919	665	800	579	699	376	427	282	320	62	77
108	10800	Waterbury Way	652	766	568	670	496	589	317	362	241	273	54	65
109	10800	Waterbury Lake	652	766	568	670	496	589	317	362	241	273	54	65
110	11400	East Roseville Parkway	566	654	492	572	429	503	314	368	231	276	80	104
111	11400	E. Roseville Parkway Pond	566	654	492	572	429	503	314	368	231	276	80	104
112	11700	Treelake Office Lane	566	654	492	572	429	503	314	368	231	276	80	104
113	11700	Treelake Office Lane Pond	566	654	492	572	429	503	314	368	231	276	80	104
	LINDA	CR/HAZEL AVE. TRIB. (Sac. Cty)												
114	0	Linda Creek Confluence	920	1146	806	1002	708	879	519	646	391	494	150	200
115	400	Oak Avenue	920	1146	806	1002	708	879	519	646	391	494	150	200

TABLE 2-7 (Continued)

No.	Distance From Mouth (ft)	Location Description	500-Year 1989 (cfs)	500-Year Future (cfs)	200-Year 1989 (cfs)	200-Year Future (cfs)	100-Year 1989 (cfs)	100-Year Future (cfs)	25-Year 1989 (cfs)	25-Year Future (cfs)	10-Year 1989 (cfs)	10-Year Future (cfs)	2-Year 1989 (cfs)	2-Year Future (cfs)
	LINDA CR/ORANGEVALE TRIB. (Sac. Cty)													
116	0	Linda Creek Confluence	1696	1815	1481	1587	1298	1393	655	727	475	538	241	284
117	900	Oak Avenue	865	924	756	809	664	711	376	427	282	320	99	110
118	3300	Filbert Avenue	813	868	711	760	624	668	358	406	269	305	90	100
119	4300	Chestnut Avenue	896	973	784	853	689	750	336	383	254	288	92	101
120	5500	Walnut Avenue (North)	383	386	337	338	297	298	219	220	167	167	66	67
120	5500	Walnut Avenue (South)	424	535	371	467	326	409	238	299	181	229	71	95
121	6700	Main Avenue (North)	287	290	252	254	223	224	164	165	125	125	50	50
121	6700	Main Avenue (South)	297	375	260	327	228	286	167	209	127	160	50	67
	ANTELOPE CREEK													
122	0	Miners Ravine/Dry Cr.	4490	5027	3726	4195	3075	3486	1979	2244	1242	1426	320	399
123	1400	Harding Blvd.	4487	5025	3724	4193	3074	3485	1978	2243	1241	1425	320	399
124	2300	Atlantic Street	4485	5024	3722	4192	3072	3483	1977	2242	1241	1425	320	399
125	5000	County Dump Road	4472	5015	3712	4184	3065	3477	1973	2236	1238	1421	319	397
126	9600	Highway 65	4484	5037	3729	4207	3086	3500	1982	2243	1243	1425	320	399
127	10300	Springview Drive	4363	4911	3722	4209	3176	3612	2526	2653	1620	1721	320	399
128	10800	Rocklin City Trib. Conf.	4342	4883	3704	4186	3161	3592	2483	2618	1594	1701	317	395
130	15800	Sunset Blvd.	4508	5070	3750	4232	3104	3519	2425	2570	1559	1673	316	394
133	22800	Clover Valley Cr. Confluence	4653	5234	3849	4348	3165	3593	2135	2401	1400	1587	309	385
134	23600	Midas Avenue	3360	3847	2804	3229	2330	2703	1544	1779	1018	1186	225	293
135	25700	Southern Pacific Railroad	3317	3799	2773	3196	2310	2683	1528	1763	1008	1175	222	291
136	26500	Yankee Hill Road	3303	3783	2763	3185	2303	2676	1523	1757	1004	1171	220	290
137	27600	Atchinson Dairy Dam	3260	3735	2732	3152	2283	2655	1507	1741	993	1160	217	287
138	28900	Unnamed Road	3218	3688	2702	3119	2262	2634	1492	1725	983	1148	214	284
139	31800	Delmar Avenue	3173	3652	2670	3088	2242	2607	1505	1761	1018	1196	215	285
140	34300	Sierra College Blvd.	3073	3544	2591	3002	2180	2541	1477	1728	986	1165	210	279
141	37000	King Road	2989	3446	2529	2927	2137	2485	1465	1715	962	1137	207	275
	ANTELOPE CR/CLARK TUNNEL RD TRIB.													
142	0	Antelope Creek Confluence	2975	3431	2520	2926	2132	2496	1506	1763	1004	1200	205	273
143	100	Barker Road	1780	2202	1504	1879	1268	1603	883	1115	567	745	118	180
144	1300	Humphrey Road	1649	2114	1382	1802	1155	1537	934	1218	638	864	112	178
145	1700	Humphrey Trib. Confluence	1619	2073	1358	1769	1136	1510	913	1197	625	851	111	174
148	7000	Colwell Road	1141	1578	963	1360	811	1174	599	870	423	643	81	143
149	10000	English Colony Way	1024	1492	881	1308	759	1152	520	770	369	576	76	133
150	12800	Clark Tunnel Road	395	658	342	581	297	515	218	382	158	293	51	112

TABLE 2-7 (Continued)

No.	Distance From Mouth (ft)	Location Description	500-Year 1989 (cfs)	500-Year Future (cfs)	200-Year 1989 (cfs)	200-Year Future (cfs)	100-Year 1989 (cfs)	100-Year Future (cfs)	25-Year 1989 (cfs)	25-Year Future (cfs)	10-Year 1989 (cfs)	10-Year Future (cfs)	2-Year 1989 (cfs)	2-Year Future (cfs)
	ANTELOPE CR/ROCKLIN CITY TRIB.													
151	0	Antelope Creek Confluence	246	312	216	275	190	243	140	180	108	140	49	64
152	2700	Taylor Road	185	234	162	206	142	182	105	135	81	105	37	48
153	3800	Taylor Road	154	195	135	172	119	152	88	113	67	87	31	40
154	4500	Sunset Blvd.	92	117	81	103	71	91	52	67	40	52	18	24
	ANTELOPE CR./CLOVER VALLEY CR.													
155	0	Antelope Cr. Confluence	1266	1379	1045	1139	857	934	592	640	398	432	32	63
156	400	Argonaut Avenue	1261	1373	1042	1134	855	931	590	638	397	431	34	64
157	2200	Footbridge and Weir	1237	1342	1024	1111	842	915	582	627	391	423	46	70
158	4300	Midas Avenue	1227	1330	1016	1102	837	908	578	623	388	420	50	72
159	4700	Abandoned Stone Bridge	1224	1325	1015	1100	837	908	578	623	389	420	55	75
160	5600	Unnamed Bridge	1207	1303	1003	1084	829	898	572	616	385	415	64	80
161	6500	Clover Valley Det. Pond	1199	1292	997	1076	825	892	570	612	384	412	69	82
162	7700	Creekwood Drive	1182	1270	985	1060	817	882	564	605	380	407	78	87
163	12000	Rawhide Road	1073	1172	895	981	744	819	516	566	346	380	71	81
164	12500	Rawhide Road Det. Pond	1058	1158	883	970	734	810	509	560	342	377	70	80
165	25600	Unnamed Road	696	827	578	691	478	576	322	386	243	298	48	58
166	28000	Sierra College Blvd	578	694	494	600	422	519	307	378	218	273	66	87
167	28500	English Colony Way	578	694	494	600	422	519	307	378	218	273	66	87
	ANTELOPE CREEK CONTINUED													
169	38700	Clark Tunnel Rd. Trib. Conflue	1195	1229	1016	1048	864	893	624	648	437	455	87	93
170	40600	Barker Road	1059	1118	903	957	770	819	556	592	390	419	80	88
171	42500	Citrus Colony Road	1001	1084	856	931	732	800	506	755	360	566	78	88
172	47900	English Colony Way	492	625	432	549	380	484	279	358	210	274	76	103
	ANTELOPE CR./HUMPHREY TRIB.													
173	0	Clark Tunnel Rd. Trib. Conflue	487	604	421	527	364	462	264	337	194	251	68	94
174	1700	Sandy Road	341	423	295	369	255	323	185	236	135	176	47	65
175	3300	Mardell Lane	292	362	252	316	218	277	158	202	116	151	41	56
176	3700	Colwell Road	243	302	210	264	182	231	132	168	97	126	34	47
177	6300	English Colony Way	146	181	126	158	109	138	79	101	58	75	20	28
	MINERS RAVINE													
178	0	Antelope Cr./Dry Cr.	11991	12943	9752	10505	7844	8428	5282	5644	3384	3697	1261	1346
179	200	Harding Blvd.	11989	12937	9750	10500	7843	8424	5281	5642	3383	3696	1261	1345
180	1500	Interstate 80	11980	12914	9743	10483	7837	8412	5278	5634	3381	3691	1261	1342
181	2800	Eureka Way	11979	12900	9745	10475	7842	8409	5291	5641	3384	3689	1121	1340
182	3800	Secret Ravine Confluence	11950	12864	9717	10423	7815	8344	4343	4755	2625	2813	1096	1339
183	5300	Sunrise Avenue	9468	10338	7676	8342	6149	6642	3753	4170	2307	2497	965	1141
184	7000	Boardman Tributary	2453	2808	1989	2271	1594	1814	1130	1266	672	775	770	843

TABLE 2-7 (Continued)

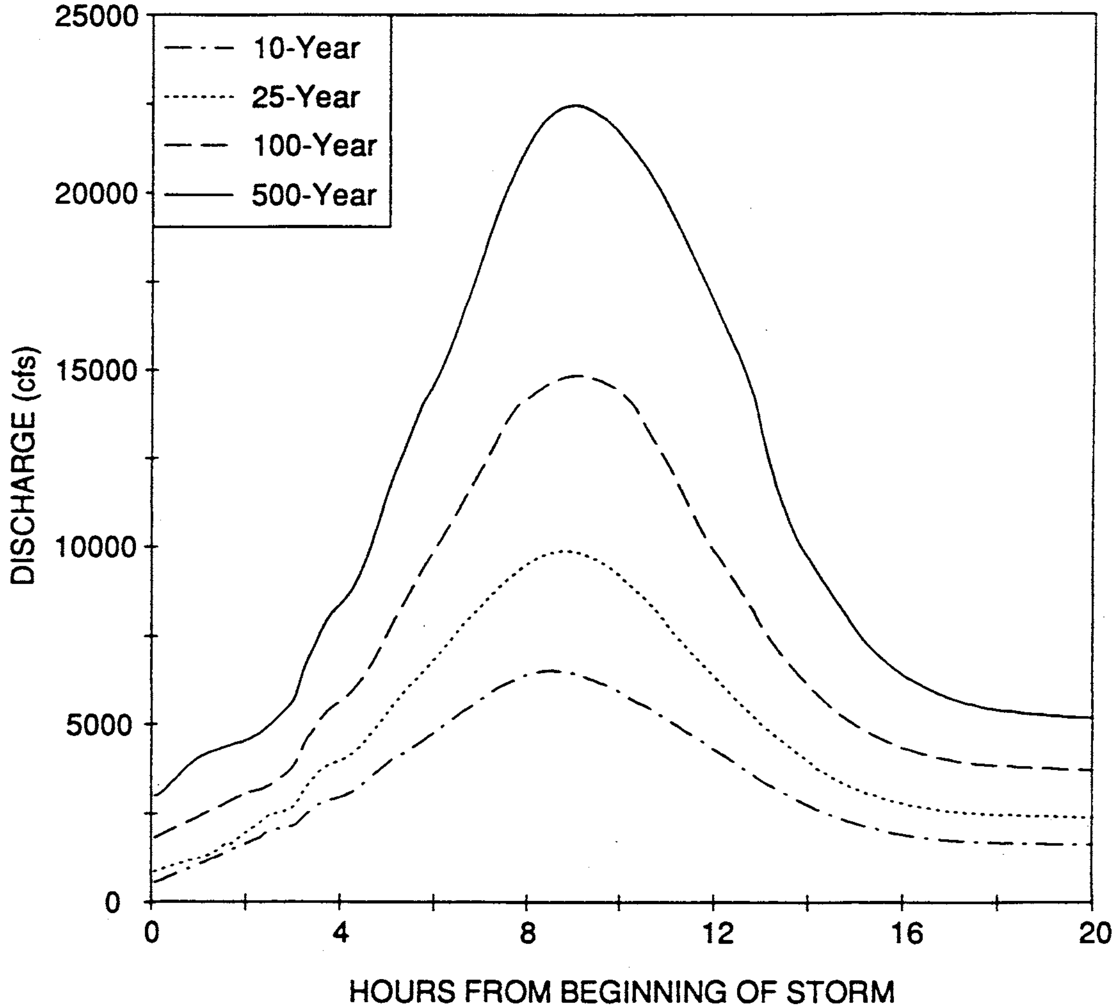
No.	Distance From Mouth (ft)	Location Description	500-Year 1989 (cfs)	500-Year Future (cfs)	200-Year 1989 (cfs)	200-Year Future (cfs)	100-Year 1989 (cfs)	100-Year Future (cfs)	25-Year 1989 (cfs)	25-Year Future (cfs)	10-Year 1989 (cfs)	10-Year Future (cfs)	2-Year 1989 (cfs)	2-Year Future (cfs)
185	9000	East Roseville Parkway	5991	6887	4854	5581	3885	4468	2630	3028	1685	1867	763	833
186	18200	Sierra College Blvd.	5894	6883	4789	5577	3847	4465	2577	2973	1656	1837	730	801
187	18300	Cavitt Stallman Trib.	5894	6883	4789	5577	3847	4465	2577	2973	1656	1837	730	801
188	18600	Cavitt & Stallman Road	5093	5980	4093	4815	3241	3823	2276	2681	1520	1698	730	801
190	23400	Shadow Oaks Lane	4940	5787	3985	4684	3171	3745	2215	2619	1478	1654	723	347
191	28900	Barton Road	4762	5565	3865	4542	3101	3671	2147	2557	1485	1770	707	708
192	31300	Tall Pine Lane	4661	5448	3786	4452	3041	3603	2105	2510	1457	1740	706	707
193	33000	Carolinda Drive	4560	5332	3708	4362	2982	3535	2063	2462	1429	1710	705	706
194	34800	Itchy Acres Road	4474	5238	3643	4291	2936	3484	2029	2426	1409	1694	641	643
196	35500	Miners Ravine Road	4426	5184	3607	4249	2909	3453	2009	2404	1397	1682	630	632
197	36800	Leibinger Lane	4378	5129	3570	4207	2881	3421	1989	2383	1384	1669	619	621
199	39700	Auburn Folsom Road	4266	4976	3456	4059	2766	3278	2000	2366	1323	1493	597	599
200	41700	Oak Lake	4148	4846	3369	3960	2706	3206	1947	2310	1292	1461	595	597
201	43000	Old Bridge	4067	4782	3323	3933	2689	3210	1893	2252	1260	1428	747	748
202	43200	Cottonwood Lake	4042	4758	3307	3918	2680	3202	1880	2238	1253	1420	765	766
203	44400	Auburn Folsom Road	4087	4772	3335	3925	2694	3204	1866	2223	1244	1411	784	785
204	45600	Confluence w/ lake trib. (MR1	3891	4551	3177	3746	2568	3061	1789	2141	1199	1364	783	783
205	56000	Moss Lane	3713	4364	3041	3610	2468	2967	1710	2055	1152	1314	538	429
207	59900	Dick Cook Road	2419	2950	2078	2587	1787	2277	1227	1525	860	1002	543	544
208	61500	Auburn Folsom Road	2277	2773	1961	2439	1691	2154	1181	1473	831	971	542	543
209	62400	Placer Canyon Parkway	2135	2596	1844	2291	1596	2031	1133	1419	801	939	542	542
210	67600	Horseshoe Bar Road	1749	2129	1506	1868	1299	1645	890	1142	647	771	582	582
211	71700	Auburn Folsom Road	1362	1715	1171	1493	1008	1304	730	955	543	656	186	214
212	73300	King Road	1265	1611	1094	1407	949	1234	694	910	510	683	87	122
213	79400	Penryn Rock Springs Rd.	365	488	317	428	277	376	199	275	147	208	50	77
214	80200	Newcastle Road	219	293	190	257	166	226	119	165	88	125	30	46
	MINERS RAVINE/BOARDMAN TRIB.													
215	0	Miners Ravine Confluence	557	695	480	606	414	530	302	387	217	288	71	110
216	800	East Roseville Parkway	529	660	456	576	393	504	287	368	206	274	67	105
	MINERS RAV./CAVITT & STALLMAN TRIB.													
217	0	Miners Ravine Confluence	885	989	728	826	595	688	539	648	355	425	129	178
218	2400	Hidden Valley Place	843	943	693	787	566	655	508	610	335	402	121	167
219	3100	Baywood Road	801	896	658	748	537	621	477	573	316	379	113	155
220	3700	S Bar B Lane	759	850	623	709	508	588	446	535	296	355	106	144
221	4500	Kokula Lane	717	804	588	669	479	554	415	497	277	332	98	133
222	5100	Crestview Lane	675	758	554	630	451	521	384	460	257	309	90	122
223	9300	Barton Road	671	872	577	760	496	665	360	486	260	360	85	130

TABLE 2-7 (Continued)

No.	Distance From Mouth (ft)	Location Description	500-Year 1989 (cfs)	500-Year Future (cfs)	200-Year 1989 (cfs)	200-Year Future (cfs)	100-Year 1989 (cfs)	100-Year Future (cfs)	25-Year 1989 (cfs)	25-Year Future (cfs)	10-Year 1989 (cfs)	10-Year Future (cfs)	2-Year 1989 (cfs)	2-Year Future (cfs)
	MINERS RAVINE/LAKE TRIB. (MR21)													
224	0	Miners Ravine Conf.	410	523	358	459	314	404	230	298	170	226	61	86
225	200	Auburn Folsom Road	462	589	403	516	353	454	258	335	192	254	68	96
226	300	South Lake Circle	462	589	403	516	353	454	258	335	192	254	68	96
	SECRET RAVINE													
227	0	Miners Ravine Confluence	6524	6695	5267	5419	4197	4332	2865	2954	1890	1967	463	595
228	1400	East Roseville Parkway	6521	6693	5266	5417	4196	4331	2864	2953	1889	1967	463	595
229	13500	Sucker Ravine Confluence	6288	6462	5134	5305	4151	4320	2774	2991	1864	1977	457	588
230	16200	Aguilar Rd. Trib. Conf.	5600	6122	4577	5000	3706	4045	2495	2729	1659	1762	354	467
231	17600	Rocklin Road	5158	5736	4195	4701	3374	3820	2304	2611	1552	1750	329	440
232	23300	Sierra College Blvd.	5143	5747	4188	4703	3375	3814	2263	2577	1525	1729	326	437
233	28800	Private Road	4832	5542	3942	4555	3183	3714	2115	2452	1427	1654	312	422
234	29200	Private Road	4813	5523	3926	4541	3171	3705	2106	2445	1421	1649	310	421
235	30800	Brace Road	4681	5385	3822	4448	3090	3649	2031	2381	1371	1611	304	412
236	32600	Horseshoe Bar Road	4593	5303	3780	4429	3088	3684	1974	2332	1333	1581	297	405
237	33400	Loomis Trib. Confluence	4577	5289	3768	4418	3078	3676	1967	2326	1329	1578	295	404
238	33500	King Rd. Trib. Conf.	4294	5041	3516	4199	2853	3481	1853	2226	1252	1516	248	378
239	38600	King Road	3418	4019	2846	3402	2358	2877	1580	1965	1071	1370	209	322
241	40000	Penryn Road	3353	3961	2804	3364	2337	2856	1564	1957	1063	1369	207	321
242	40500	Harris/Boulder Cr. Road	3334	3944	2792	3353	2331	2850	1559	1955	1060	1368	206	320
243	40700	Penryn Trib. Confluence	3332	3955	2800	3359	2346	2852	1368	1784	929	1243	206	320
244	43300	Boulder Creek Road	2780	3285	2338	2791	1961	2371	1196	1617	814	1138	172	262
245	48500	Brennans Road	1570	1840	1341	1586	1146	1369	731	1128	501	824	98	142
246	48900	Rock Springs Road	1530	1799	1308	1551	1118	1340	718	1113	492	813	96	139
247	50400	Meadow Lane	1410	1676	1206	1448	1032	1254	672	1061	461	779	88	129
248	51300	Los Puentes Road	1425	1834	1227	1596	1058	1394	643	1027	442	757	91	141
249	55300	Newcastle Road	1240	1689	1071	1477	927	1297	666	943	487	709	163	268
250	57700	Powerhouse Road	868	1182	750	1034	649	908	466	660	341	496	114	188
	SECRET RAVINE/SUCKER RAVINE													
251	0	Secret Ravine Conf.	1582	1798	1345	1545	1144	1330	753	1153	516	840	457	588
252	1000	China Garden Road	1575	1790	1340	1539	1140	1326	748	1147	513	836	414	535
253	1200	Interstate 80	1572	1787	1338	1537	1138	1324	747	1145	512	835	400	517
254	2200	Oakridge Street	1571	1786	1337	1536	1138	1324	745	1143	510	834	395	510
255	2600	Lakeside Drive	1589	1823	1356	1572	1157	1358	735	1132	504	826	318	418
256	3950	Rocklin Road	1596	1848	1365	1598	1169	1385	716	1111	491	812	179	247
257	4300	Quarry Lake	1582	1835	1354	1587	1160	1377	711	1105	487	808	177	244
258	4700	Super Span	1568	1821	1343	1577	1151	1369	704	1097	483	803	174	241
259	7450	Sierra Meadows Drive	1527	1781	1310	1545	1125	1344	686	1077	471	790	167	232
260	10800	Dominguez Road	1408	1791	1223	1560	1065	1363	597	973	410	721	142	202
261	11000	Loomis Trib. Conf.	1431	1793	1244	1562	1085	1366	589	963	405	715	140	200
263	13400	Pacific Street	803	689	697	594	607	514	553	919	380	685	79	81

TABLE 2-7 (Continued)

No.	Distance From Mouth (ft)	Location Description	500-Year 1989 (cfs)	500-Year Future (cfs)	200-Year 1989 (cfs)	200-Year Future (cfs)	100-Year 1989 (cfs)	100-Year Future (cfs)	25-Year 1989 (cfs)	25-Year Future (cfs)	10-Year 1989 (cfs)	10-Year Future (cfs)	2-Year 1989 (cfs)	2-Year Future (cfs)
264	14800	Bankhead Road	734	634	638	548	556	476	523	883	360	661	74	74
265	15200	Sierra College Blvd.	711	615	619	533	540	463	513	870	353	652	72	72
266	19000	Saunders Avenue	695	876	606	754	531	651	211	455	148	364	69	72
267	20200	King Road	709	901	618	776	541	669	211	455	148	364	70	73
	SECRET RAV./SUCKER RAV./LOOMIS TRIB.													
268	0	Sucker Ravine Confluence	497	941	434	827	380	730	278	542	210	422	88	202
270	4400	Sierra College Blvd.	273	518	238	456	209	402	153	298	116	232	48	111
	SECRET RAVINE/AGUILAR RD. TRIB.													
271	0	Secret Ravine Conf.	929	1287	733	994	566	744	543	907	374	677	23	49
272	700	Aguilar Road	891	1223	706	950	549	718	529	890	364	666	23	50
273	2400	Foothill Road	815	1095	654	863	516	666	499	852	344	640	23	53
274	4100	El Don Road	758	999	614	798	491	627	476	824	328	621	22	55
275	4100	El Don Detention Pond	738	970	605	786	491	630	461	805	318	608	22	61
276	6100	Sierra College Blvd.	624	768	537	668	462	583	334	423	242	316	79	121
	SECRET RAVINE/LOOMIS TRIB.													
277	0	Secret Ravine Conf.	673	996	565	842	473	710	373	689	258	529	64	99
278	1200	Interstate 80	622	921	522	778	437	656	354	663	245	511	60	92
279	2800	Laird Street	586	866	492	732	411	618	339	643	235	497	56	86
280	3600	King Road	549	812	461	686	386	579	326	625	226	485	53	81
	SECRET RAVINE/KING ROAD TRIB.													
281	0	Secret Ravine Conf.	1838	1994	1584	1727	1367	1500	782	1184	535	860	41	378
282	3900	Rancho Verde Road	1707	1855	1471	1607	1270	1395	743	1142	509	832	41	345
283	5400	Val Verde Road	558	659	483	576	419	505	303	368	221	274	73	99
284	6300	King Road	502	593	435	518	377	455	273	331	199	247	66	89
	SECRET RAVINE/PENRYN TRIB.													
285	0	Secret Ravine Conf.	1329	1830	1151	1603	999	1410	580	952	399	707	87	140
286	4700	Rock Springs Road	1413	2026	1203	1757	1024	1528	729	1116	495	809	96	176
287	5600	East/West Forks Conf.	1240	1890	1046	1637	881	1421	647	1042	453	771	88	170
	SECRET RAV./E. FORK PENRYN TRIB.													
288	0	West Fork Confluence	338	459	293	403	255	356	185	262	135	198	46	75
289	900	Fairview Lane	303	411	263	361	228	319	166	235	121	177	41	67
290	3700	Gilardi Road	125	169	108	148	94	131	68	97	50	73	17	28
	SECRET RAV./W. FORK PENRYN TRIB.													
291	0	East Fork Confluence	823	1299	700	1137	595	999	440	738	315	560	58	119
292	200	Interstate 80	819	1292	697	1131	593	994	438	735	314	557	58	118
293	1400	Gilardi Road	773	1317	662	1159	567	1024	416	757	295	571	90	217



10-, 25-, 100-, AND 500 YEAR FLOOD HYDROGRAPHS AT VERNON STREET GAGE
FIGURE 2-8

TABLE 2-8

SUBBASIN PEAK FLOWS

Basin ID	Subbasin Description	500-Year 1989 (cfs)	500-Year Future (cfs)	100-Year 1989 (cfs)	100-Year Future (cfs)	25-Year 1989 (cfs)	25-Year Future (cfs)	10-Year 1989 (cfs)	10-Year Future (cfs)	2-Year 1989 (cfs)	2-Year Future (cfs)
LC1	Auburn-Folsom Road	455	666	349	510	255	377	193	291	79	125
LC5	Barton Road	701	818	538	631	395	465	295	352	112	137
LC10	Wedgewood Drive	200	283	154	220	114	164	85	126	30	50
LC15	Cherry Avenue	951	1191	712	912	513	662	374	496	123	189
LC20	Walnut Avenue	424	535	326	409	238	299	181	229	71	95
LC25	Walnut Avenue	383	386	297	298	219	220	167	167	66	67
LC30	Oak Avenue	209	209	157	157	113	113	83	83	29	29
LC35	Oak Avenue	920	1146	708	879	519	646	391	494	150	200
LC40	Hazel Avenue	530	536	396	402	285	290	210	214	74	77
LC45	Indian Creek Drive	932	932	719	719	530	530	398	398	151	151
LC50	Treelake Road	566	654	429	503	314	368	231	276	80	104
LC55	Sierra College Blvd	514	980	383	758	279	557	201	428	64	177
LC60	Linda Creek	213	222	162	171	119	125	88	93	32	35
LC65	Country Lake Drive	401	401	308	309	227	227	172	172	66	67
LC70	Old Auburn Road	152	152	117	117	87	87	66	66	25	25
LC80	Champion Oaks Drive	1066	1427	824	1089	607	806	465	626	187	272
LC82	Strap Ravine	146	193	113	146	83	108	65	84	29	39
LC85	Rocky Ridge Drive	316	389	243	297	180	220	139	171	62	77
LC90	Oak Ridge Drive	387	469	300	364	220	269	168	207	74	92
LC95	Cirby Creek	259	407	199	310	149	228	117	178	59	92
CC1	Douglas Boulevard	280	568	215	435	158	325	117	254	41	119
CC2	Douglas Boulevard	230	708	179	531	133	398	100	312	37	160
CC5	East Roseville Parkway	435	631	326	471	243	344	189	268	87	137
CC10	Huntington Drive	547	546	407	407	302	302	234	234	104	105
CC15	Sierra Gardens Drive	362	457	275	341	203	251	158	196	80	97
CC20	Douglas Boulevard	488	1128	378	846	281	630	219	493	96	257
CC25	Sierra Gardens Drive	118	127	88	95	66	71	51	55	25	27
CC30	Loretto Drive	407	407	305	305	227	227	177	177	88	88
CC35	Oak Ridge Drive	314	314	235	235	175	175	136	136	64	64
CC40	Linda Creek	405	405	303	303	227	227	177	177	87	87
CC45	Dry Creek	1856	1882	1429	1450	1062	1079	829	843	387	397
SR1	Barton Road	851	1312	652	1020	476	751	356	578	135	240

TABLE 2-8 (Continued)

Basin ID	Subbasin Description	500-Year 1989 (cfs)	500-Year Future (cfs)	100-Year 1989 (cfs)	100-Year Future (cfs)	25-Year 1989 (cfs)	25-Year Future (cfs)	10-Year 1989 (cfs)	10-Year Future (cfs)	2-Year 1989 (cfs)	2-Year Future (cfs)
SR5	Sierra College Blvd	976	1245	723	947	524	690	381	515	132	197
SR8	East Roseville Parkway	160	337	124	254	92	189	68	148	24	68
SR10	East Roseville Parkway	381	784	295	597	218	444	164	347	64	168
SR15	Eureka Road	196	279	153	215	113	160	88	125	35	57
SR20	McLaren Drive	311	428	241	328	178	243	137	189	57	87
SR25	Linda Creek	96	113	72	84	53	62	41	48	18	21
MR1	Rock Springs Road	365	488	277	376	199	275	147	208	50	77
MR5	King Road	918	1205	691	931	501	682	366	512	123	188
MR10	Horseshoe Bar Road	564	888	417	686	302	503	217	378	68	142
MR15	Dick Cook Road	1162	1549	859	1185	621	865	448	644	146	236
MR19	Lake Trib.	807	1017	592	768	430	560	309	411	100	145
MR20	Confluence with MR19 Trib.	990	1259	715	939	519	684	370	499	117	175
MR21	Cavitt Stallman Road	1026	1308	785	1009	574	744	426	564	152	214
MR24	Barton Road	671	872	496	665	360	486	260	360	85	130
MR25	Sierra College Blvd	699	848	513	636	375	464	269	340	89	119
MR29	Auburn-Folsom Road	1067	1270	823	988	604	728	455	556	172	213
MR30	Barton Road	830	998	604	743	439	541	315	395	105	138
MR31	Sierra College Blvd	946	1153	703	876	512	642	372	475	129	178
MR35	Boardman Trib.	557	695	414	530	302	387	217	288	71	110
MR36	Confluence with Boardman Trib.	325	571	235	439	171	323	121	243	36	97
MR37	Confluence with Secret Ravine	101	233	76	178	55	132	40	103	13	47
MR40	Mouth of Miners Ravine	381	1006	296	756	217	568	166	445	64	229
SE1	Gilardi Road	773	1317	567	1024	416	757	295	571	90	217
SE5	E. Fork Penryn Trib. at Secret R.	356	483	268	375	195	276	142	208	48	79
SE7	Rock Springs Road	330	554	254	421	185	312	138	241	47	94
SE10	Conf. w/E. Fork Penryn Trib.	402	521	310	403	228	298	171	228	61	86
SE15	Boulder Creek Road	410	700	303	539	217	396	157	301	49	117
SE20	Newcastle Road	1240	1689	927	1297	666	943	487	709	163	268
SE25	Brennans Road	478	701	354	541	254	395	184	297	59	109
SE26	Boulder Creek Road	418	531	312	407	227	298	164	222	53	81
SE30	King Road	547	606	420	469	307	344	230	261	83	101
SE35	Confluence with King Rd. Trib.	268	336	207	261	152	193	113	148	40	59
SE40	Horseshoe Bar Road	686	1000	514	772	375	569	278	434	107	181
SE44	King Rd. Trib. at Val Verde Rd.	558	659	419	505	303	368	221	274	73	99

TABLE 2-8 (Continued)

Basin ID	Subbasin Description	500-Year 1989 (cfs)	500-Year Future (cfs)	100-Year 1989 (cfs)	100-Year Future (cfs)	25-Year 1989 (cfs)	25-Year Future (cfs)	10-Year 1989 (cfs)	10-Year Future (cfs)	2-Year 1989 (cfs)	2-Year Future (cfs)
SE45	King Road Trib. at Secret Ravine	1482	1579	1121	1204	817	880	599	652	206	234
SE50	Loomis City Boundary	1219	1550	923	1196	673	877	493	661	165	250
SE51	Sierra College Blvd	727	1015	553	785	403	576	296	439	99	169
SE52	Rocklin Road	328	460	248	355	179	260	134	199	52	88
SE55	Aquilar Trib. at Sierra Coll. Bd.	624	768	462	583	334	423	242	316	79	121
SE56	Aguilar Trib. at Secret Ravine	642	949	495	734	362	541	273	418	102	182
SE57	Confluence with Sucker Ravine	164	293	126	225	92	167	69	130	24	56
SE60	Sucker R./E. Trib. at Sucker Rav.	497	1045	380	801	278	598	210	468	88	230
SE65	Sucker Ravine at Grange Ave.	648	1238	495	926	368	688	286	536	131	263
SE66	Sucker R. at Conf. with E. Trib.	529	819	391	632	281	463	205	354	70	155
SE70	Sucker Rav. at Rocklin Road	652	1155	506	886	374	660	289	516	136	252
SE76	Sucker Ravine at Interstate 80	268	338	207	259	153	192	119	149	50	67
SE80	Rocklin City Boundary	575	855	438	659	321	485	240	373	94	156
SE85	Mouth of Secret Ravine	434	494	326	375	237	273	173	203	59	76
AC1	Clark Tun. Rd. Trib. at Cl. Tun. R	395	658	297	515	218	382	158	293	51	112
AC2	CTR Trib. at English Colony Rd	602	1024	442	796	324	587	230	443	70	169
AC4	CTR Trib. at Colwell Road	350	492	269	381	196	282	146	216	52	84
AC5	CTR Trib. Conf. w/Humphrey Rd	973	1208	728	923	528	673	387	502	135	187
AC10	CTR Trib. Conf. with Antelope Cr	189	231	142	177	102	129	75	96	26	36
AC15	English Colony Road	492	625	380	484	279	358	210	274	76	103
AC16	Colwell Road	369	447	280	344	205	253	151	189	53	68
AC20	Citrus Colony Road	601	702	466	542	344	401	260	307	97	116
AC25	Confluence w/Clark Tun. Rd Trib.	296	422	219	324	158	237	114	178	37	66
AC30	Delmar Avenue/Loomis	544	605	411	462	300	336	220	250	75	91
AC35	Conf. w/Clover Valley Creek	740	921	566	713	412	523	310	399	125	167
AC41	Rocklin City Boundary	615	779	474	607	350	450	269	349	123	161
AC45	Mouth of Antelope Cr.	445	611	333	470	243	345	177	262	63	110
CV1	English Colony Road	578	694	422	519	307	378	218	273	66	87
CV5	Wood Glen Drive	384	465	273	340	199	247	139	175	40	53
CV6	Creekwood Drive	400	564	286	420	207	302	146	222	44	77
CV10	Mouth of Clover Valley	367	394	279	300	203	218	150	164	54	63
DC4	Parry Street	778	1414	605	1071	450	800	351	625	167	312
DC5	Confluence with Cirby Cr.	551	964	431	740	319	554	248	435	122	219
AC40	Sunset Blvd	1142	1417	886	1101	656	817	504	634	227	288

TABLE 2-8 (Continued)

Basin ID	Subbasin Description	500-Year 1989 (cfs)	500-Year Future (cfs)	100-Year 1989 (cfs)	100-Year Future (cfs)	25-Year 1989 (cfs)	25-Year Future (cfs)	10-Year 1989 (cfs)	10-Year Future (cfs)	2-Year 1989 (cfs)	2-Year Future (cfs)
DC10	Vernon Avenue	1206	1228	930	935	690	694	537	541	251	258
DC15	SPRR Bridge	966	1442	749	1107	557	827	433	648	199	312
DC20	Conf. with DC25/DC80 Tribs.	1033	1550	800	1202	592	898	457	703	211	344
DC25	Dry Creek DC25 Trib.	1259	1344	959	1030	697	752	526	575	218	258
DC35	Cook Riolo Road	388	432	300	332	222	246	170	190	64	75
DC40	Dry Creek DC40 Trib.	372	407	289	316	214	234	163	180	62	71
DC45	Confluence with DC40 Trib.	243	271	188	211	137	155	104	118	38	46
DC50	Confluence with DC55 Trib.	278	333	207	254	148	184	108	137	35	50
DC55	Dry Creek DC55 Trib.	508	760	390	590	286	437	212	337	76	142
DC60	Confluence with DC65 Trib.	471	687	347	525	250	382	181	288	59	113
DC65	Dry Creek DC65 Trib.	659	707	484	524	352	380	253	277	84	97
DC68	County Line Trib. at PFE Road	645	993	471	762	346	558	247	421	79	174
DC70	County Line Trib. at Watt Ave.	219	332	160	254	116	184	82	138	25	54
DC71	Mouth of County Line Trib.	229	365	177	279	130	206	98	160	35	69
DC75	Watt Avenue	381	504	282	384	202	278	146	206	45	73
DC76	Conf. with County Line Trib.	288	336	219	258	159	188	117	140	39	50
DC80	Cook Riolo Road	1742	2469	1353	1912	1005	1427	775	1115	357	532
DC85	Confluence with DC90 Trib.	203	221	152	167	109	120	80	89	27	32
DC90	Dry Creek DC90 Trib.	454	605	344	467	251	344	187	263	72	113
DC95	Sierra Creek at Walerga Road	769	943	596	727	438	537	334	414	141	180
DC96	Sierra Creek at Watt Avenue	984	1382	748	1068	548	788	404	601	144	242
DC100	Mouth of Sierra Creek	379	484	290	375	213	277	159	211	63	89
DC105	Dry Creek DC105 Trib.	699	711	530	541	388	397	288	296	110	115
DC110	Confluence with Sierra Creek	305	305	233	233	171	171	131	131	51	51
DC115	Confluence with DC105 Trib.	365	365	281	281	207	207	159	159	63	63
DC120	Q Street	477	477	369	369	269	269	203	203	75	75
DC125	Elkhorn Blvd	715	739	524	544	377	390	274	286	96	104
DC130	Rio Linda Blvd	561	579	419	435	301	311	222	232	82	88
DC135	Natomas E Main Drain	509	509	371	371	267	267	192	192	64	64

TABLE 2-9
HEC-1 COMBINATION POINTS

Combination Point		Combination Point	
Name	**Location**	**Name**	**Location**
LINDA CREEK		SECRET (Cont.)	
LCC1	LC5	SEC6	SE35
LCC2	LC10	SEC7	SE40
LCC3	LC15	SEC8	SE50
LCC4	LC25	SEC9	SE51
LCC5	LC40	SEC10	SE52
LCC6	LC45	SEC11	SE60
LCC7	LC55	SEC12	SE70
LCC8	LC70	SEC13	SE57
LCC9	LC80	SEC14	SE80
LCC9A	LC82	SECRET	SE85
LCC10	LC82	ANTELOPE CREEK	
LCC11	LC85	ACC1	AC2
LCC12	LC90	ACC2	AC4
LINDA	LC95	ACC3	AC5
STRAP RAVINE		ACC4	AC16
SRC1	SR50	ACC5	AC20
SRC2	SR85	ACC6	AC25
SRC3	SR15	ACC7	AC30
SRC4	SR20	ACC8	AC35
STRAP	SR25	ACC9	AC40
CIRBY CREEK		ACC10	AC41
CCC1A	CC5	ANTELOPE	AC45
CCC1	CC1	CLOVER VALLEY	
CCC2	CC1	CVC1	CV5
CCC3	CC3	CVC2	CV6
CCC4	CC3	DRY CREEK	
CCC5 & CCC6	CC4	DRY	MR40
CIRBY	CC4	DCC1	DC4
MINERS RAVINE		DRYCC-	DC5
MRC1	MR5	VERNON	DC10
MRC2	MR10	DCC4	DC20
MRC3	MR15	DCC5	DC35
MRC4	MR20	DCC6	DC45
MRC5	MR21	DCC7	DC50
MRC6	MR29	DCC8	DC60
MRC7	MR30	DCC9	DC75
MRC8 (SCB)	MR31	DCC10	DC70
MRC9	MR36	DCC11	DC76
MRC10	MR37	DCC12	DC85
MINERS	MR40	DCC13	DC96
SECRET RAVINE		DCC14	DC110
SEC1	SE5	DCC15	DC115
SEC2	SE7	DCC16	DC120
SEC3	SE25	DCC17	DC125
SEC4	SE26	DCC18	DC130
SEC5	SE30	DCC19	DC135

CHAPTER 3
PROBLEMS

Flooding problems include: inadequate bridges and culverts subject to damage by overtopping and structural damages to homes and businesses.

Inadequate bridges and culverts may be damaged due to overtopping of the structure and may cause flooding due to backwater. Overtopping of the structure can result in the road being closed, thus impeding traffic and restricting emergency access to an area.

When structures are in the area flooded by backwater from an inadequate bridge or culvert, or when they have been built in the floodplain area along a channel, they will be impacted by flood flows that surpass certain levels.

SUMMARY OF 1986 FLOODING PROBLEMS

The flood of February 1986 caused damage throughout the Dry Creek watershed, but the most severe damage was located in the lower reaches of the watershed, in the City of Roseville and downstream in Sacramento County.

Nearly all of the bridges and culverts in the watershed were overtopped. Thirty bridges and culverts were damaged by the flood and the culverts at Rocky Ridge Drive in Roseville washed out completely. Street cave-ins, caused by flow over the street, occurred at a number of locations and two of the bridges over Dry Creek were damaged. Bridge and culvert overtopping closed many major streets in the watershed, including Riverside Avenue, Harding Boulevard, Darling Way, Douglas Boulevard, Vernon Street, Sierra College Boulevard, and many others.

Flooding along Dry Creek began in Roseville with 25 homes or apartments on the south side of Dry Creek upstream of Folsom Road being in the flooded area. Most of the major bridges over Dry Creek in Roseville and downstream were closed either because the bridge itself was overtopped or because the street on one end or the other of the bridge was flooded. A motorist was killed in Roseville when he attempted to cross the closed Harding Boulevard bridge in his four wheel drive pickup. Several homes were flooded along Dry Creek between Roseville and Sacramento County. The most severe flooding along Dry Creek itself probably occurred in the Rio Linda area of Sacramento County where all homes on Cherry Island were flooded and over 200 homes and businesses along Elkhorn and Rio Linda Boulevards were flooded. It is impossible to describe completely the damages in Sacramento County because the damage assessment records have been lost or destroyed. Aerial photography taken during the flood, however, indicates extensive flooding throughout the Rio Linda area from Elkhorn Boulevard to the Natomas East Main Drain.

Flooding along Cirby Creek in Roseville included over 30 homes on Elisa Way, Tina Way, Coloma Way, Coral Drive, and Salmon Drive. Insufficient capacity in the culvert at Oak Ridge Drive and the channel downstream caused Cirby Creek to go over its banks, flooding 10-15 homes along Trimble Way and Zien Court.

Linda Creek went over the north bank around 1,000 feet upstream of Oakridge Drive, flooding approximately 70 homes. The homes on Zien Court that had been flooded a few hours earlier by Cirby Creek were flooded to even higher elevations by Linda Creek. Flooding also occurred along Champion Oaks Drive and Samoa Way where homes were built prior to the 1983 flood that identified the area as being in the 100-year floodplain. Not flooded, but in serious jeopardy, were homes along Lee Way and West Colonial Parkway.

Flooding occurred in several areas in the Antelope Creek watershed, with the most severe flooding occurring on Paragon Court just upstream of Sunset Boulevard in Rocklin. Other homes along Secret Ravine in Rocklin, were flooded when it left its banks.

One home flooded along Miners Ravine just upstream of Sierra College Boulevard because of the inadequate capacity of the culvert located there. Forty-two homes were flooded along Miners Ravine between Leibinger Lane and Itchy Acres Road in the vicinity of Joe Rodgers Road.

The storm of February 1986 and the subsequent flooding in the Dry Creek watershed, have been estimated to have a recurrence interval of between 80 and 90 years in Roseville, and between 50 and 100 years at other locations in the watershed.

SUMMARY OF 100-YEAR STORM PROBLEMS

The following sections summarize the problems that were identified in the watershed based on HEC-1 model runs using both the 1989 and the Future Condition land use as described in Chapter 2.

For the purposes of this study, overtopping of culverts and bridges were determined using three methods.

1. Where HEC-2 model input data were available, the HEC-2 model and its associated bridge routines were used to estimate the flow at which a bridge or culvert overtopped.

2. On streams where FEMA flood studies had been done, the flood profiles and their associated discharges were interpolated at the bridge or culvert to determine the overtopping flood flow.

3. If data sufficient to utilize the previous two methods were not available, then FHWA standard culvert formulas and nomographs were used to determine the capacity of the bridge or culvert.

After the bridge and culvert capacities were determined, they were compared with the 100-year flood flows at the same locations, given in Table 2-7. The capacity of the bridge or culvert was next subtracted from the flood flow and any remaining flow was entered in the overtopping table. It is important to note, however, that overtopping alone does not necessarily mean that damage will occur to the road surface. It does mean that traffic on the roadway, and in particular emergency traffic, may be severely impeded and a serious safety hazard may exist.

The extent of the upstream floodplain that is affected by backwater from undersized culverts and bridges is hard to determine without detailed survey information indicating the elevation of the floodplain and dwellings and other buildings that may be in the floodplain. Because this type of information was not available as a part of this study, backwater above bridges was assumed to be a problem only in those areas that experienced problems from flooding in the 1986 storm.

Existing Problems, Based on 1989 Land Use

Flooding problems that would occur in the watershed with the 1989 base land use conditions and the 100-year design storm are classified as existing problems.

Bridges and Culverts - Overtopping and Backwater. Table 3-1 contains a listing of all bridges and culverts, with an indication next to those that have insufficient capacity to pass the 25-year and/or 100-year flood without going over the top of the roadway. The numbers in the table indicate the magnitude, in cfs, of the peak flow over the roadway at that location. A blank in the table indicates that the culvert or bridge has sufficient capacity to pass the flood.

The table indicates that nearly 70 percent of the bridges and culverts listed are inadequate to pass the 100 year flood without overtopping under 1989 land use conditions. Nearly 50 percent of the stream crossings are inadequate for even the 25-year flood.

Locations where channels and floodplains have insufficient capacity to pass the 100-year flood without impacting residences and other buildings are indicated on Figure 3-1. These areas include Miners Ravine in the vicinity of Joe Rodgers Road, Dry, Cirby, and Linda Creeks in the City of Roseville, and Dry Creek in the Rio Linda area. Each of these areas experienced moderate to severe flooding in the February 1986 flood.

Structures that will be impacted by the 100-year flood with 1989 land use conditions are essentially those that were flooded by the February 1986 flood. The recurrence intervals of the two floods are nearly the same. However, because it is larger, some additional flooded areas would be expected from the 100-year flood.

Flood impacts from the 100-year flood may increase along Miners Ravine in the vicinity of Joe Rodgers Road because of the additional construction that occurred in the floodplain between February 1986 and August 1989. More than 10 homes were built in the floodplain during that time period. Even though these homes were built to existing FEMA standards, they should be added to those that flooded in February 1986 when assessing the impact of the 100-year flood with 1989 land use conditions because of the increase in flow projected for the 100-year flood over that used by FEMA.

Future Problems, Based on General Plan Land Use

Land use changes in the watershed from the 1989 base conditions to the Future Conditions cause an eight percent overall increase in the impervious area, from 14 percent of the watershed impervious in 1989 to 22 percent for Future Conditions. This increase in impervious area, combined with the other changes described in Chapter 2, accounts for an average overall increase in all the tributaries of around 21 percent in the 100-year peak flows. The range in flow increases, however is from three percent to 60 percent, depending on the size of the watershed upstream of the location, and the amount of development that is projected to take place in that watershed. The net result of this peak flow increase is that the problems in areas with existing problems are made worse, and there are some areas without existing problems that may experience problems based on the Future Conditions' flows.

Bridges and Culverts - Overtopping and Backwater. Table 3-1 also contains a listing of the locations and magnitude of culvert and bridge overtopping in the watershed under Future land use conditions. As indicated in Table 3-1 over 70 percent of the bridges and culverts will overtop during the 100-year flood under Future land use conditions and over 50 percent will overtop during the 25-year flood. Backwater from overtopping bridges and culverts will increase slightly due to the increase in flood flows due to Future Conditions. The backwater

TABLE 3-1

BRIDGES AND CULVERTS OVERTOPPING

No.	Distance From Mouth (ft)	Location Description	Capacity	1986 Flood Damage	Overtopping Flow in cfs			
					100-yr 1989	100-yr Future	25-yr 1989	25-yr Future
	DRY CREEK							
1	8900	Rio Linda Blvd (North)	6000		1091	1831		
1	8900	Rio Linda Blvd (South)	New Bridge	Overtopped, Replaced 1990				
2	15000	Elkhorn Blvd (North)	2000	Elkhorn Blvd Flooded				
2	15000	Elkhorn Blvd (South)	16000	Between Channels				
3	16600	Curved Bridge Road (North)	14500			1146		
4	17400	Dry Creek Road (North)	16000					
4	17400	Dry Creek Road (South)	16000					
5	24400	Q Street (North)	14000					
5	24400	Q Street (South)	14000					
7	35200	28th Street (South)	15000			454		
8	35400	Elverta Road	15000			425		
11	41400	Watt Avenue	13000	Overtopped, damaged	1007	2349		
14	50300	Walerga Road	12000	Overtopped, Damaged	1973	3296		
16	58800	Cook Riolo Road	12000	Overtopped, Damaged	1950	3227		
17	67000	SPR Spur	15000					
18	67400	Atkinson Blvd	13000	Overtopped, Damaged	767	1951		
20	68900	S.P. Railroad Culverts	18000	Submerged, Damaged				
21	69900	Vernon Street	11000	Damaged	2706	3848		
22	72600	Riverside Avenue	6000	Overtopped	7825	9202	3147	3947
24	73800	Darling Way	8000	Overtopped, Damaged	2370	3289		
25	77000	Douglas Blvd.	8000	Overtopped, Damaged	2365	3279		
26	77500	Royer Park Footbridge						
27	79100	Lincoln Street	14000	New Bridge				
28	79400	Folsom Road	7000	Overtopped	3479	4361		545
29	79500	Start 1986 Damage		Marilyn, Bernice				
30	84100	Antelope Cr/Miners Ravine						
	DRY CREEK / SIERRA CREEK							
33	1400	28th Street	3000					
34	3700	Scotland Drive	1600			243		
35	5400	Delaney Drive	1000		419	816		299
36	6800	Watt Avenue	1800					
37	10300	Navaho Way						
38	11400	Elverta Road	60		654	824	421	540
39	13500	Walerga Road						
	DRY CREEK/COUNTY LINE TRIB.							
41	3200	Watt Avenue	115		515	845	231	443
42	8200	PFE Road	450		21	312		108
	DRY CREEK/DC65 TRIB.							
44	3000	Walerga Road	60		327	359	222	244
	CIRBY CREEK							
46	3000	Interstate 80	10000					
48	4600	Wanda Lee Court Footbridge	3500		618	1114		
50	7400	Sunrise Blvd.	700	Overtopped	93	398		74
51	8100	Coloma Way	650		192	463		169
52	9100	Oak Ridge Drive	600	Overtopped	266	538	29	224
53	10000	Sierra Gardens Footbridge	1000			132		
54	11800	Loretto Drive	400		451	735	227	438
56	12500	Sierra Gardens Drive	500		196	469		136
57	13900	Huntington Drive	800			184		
58	14500	Rocky Ridge Drive	550			15		
60	16400	Winchester Way	600					
61	17200	Eureka Road	1300					
62	19700	Douglas Blvd.	450					

TABLE 3-1 (Continued)

No.	Distance From Mouth (ft)	Location Description	Capacity	1986 Flood Damage	Overtopping Flow in cfs			
					100-yr 1989	100-yr Future	25-yr 1989	25-yr Future
	CIRBY CREEK/SIERRA GARDENS TRIB.							
65	1000	Douglas Blvd	150					
66	1400	Sierra Gardens Ret. Basin	150					
	LINDA CREEK							
68	1000	Sunrise Avenue	2600	Overtopped	1370	1861		149
70	2600	Oak Ridge Drive	5000					
72	4300	Sierra Gardens Footbridge	1500		2485	3055	1594	1744
73	8400	Rocky Ridge Drive	4200	Overtopped, Washed Out		424		
76	11500	Champion Oaks Drive	600	Overtopped	2697	3012	1738	1876
78	14300	Auburn Road	4400	Overtopped				
82	19800	Indian Creek Drive	3200					
83	25300	Hazel Avenue	1700	New Bridge 1988	520	765		
85	31300	Granite Avenue	1700					
86	32600	Cherry Avenue	700	New Bridge 1991	530	651	170	249
88	38600	Wedgewood Drive	500		387	531	137	238
89	42300	East Roseville Parkway	800			195		
90	43100	Barton Road	100		662	843	370	429
91	44600	Shadow Brook Place	70		572	727	340	393
92	46500	Purdy Lane	30		443	610	268	311
93	48100	Country Court	110		280	443	134	171
94	48700	Auburn Folsom Road	180		169	330	75	197
	LINDA CREEK/STRAP RAVINE							
96	1500	McClaren Drive	1400					
97	5900	Johnson Ranch Drive	4800					
98	6800	Eureka Road	5000					
99	8600	East Roseville Parkway	5000					
100	11800	Sierra College Blvd.	600		254	512		158
101	23000	Barton Road	170		482	850	306	581
	LINDA CREEK/TREELAKE TRIB.							
103	3200	Petite Way	1500					
104	5700	Old Auburn Road	1100					
105	6000	Sierra College Blvd.	340		457	645	181	244
106	9600	Swan Lake Drive	800					
108	10800	Waterbury Way	600					
110	11400	East Roseville Parkway	700					
112	11700	Treelake Office Lane	700					
	LINDA CR/HAZEL AVE. TRIB. (Sac. Cty)							
115	400	Oak Avenue	300		408	579	219	346
	LINDA CR/ORANGEVALE TRIB. (Sac. Cty)							
117	900	Oak Avenue	380		284	331		47
118	3300	Filbert Avenue	85		539	583	273	321
119	4300	Chestnut Avenue	90		599	660	246	293
120	5500	Walnut Avenue (North)	130		167	168	89	90
120	5500	Walnut Avenue (South)	130		196	279	108	169
121	6700	Main Avenue (North)	80		143	144	84	85
121	6700	Main Avenue (South)	220			66		

TABLE 3-1 (Continued)

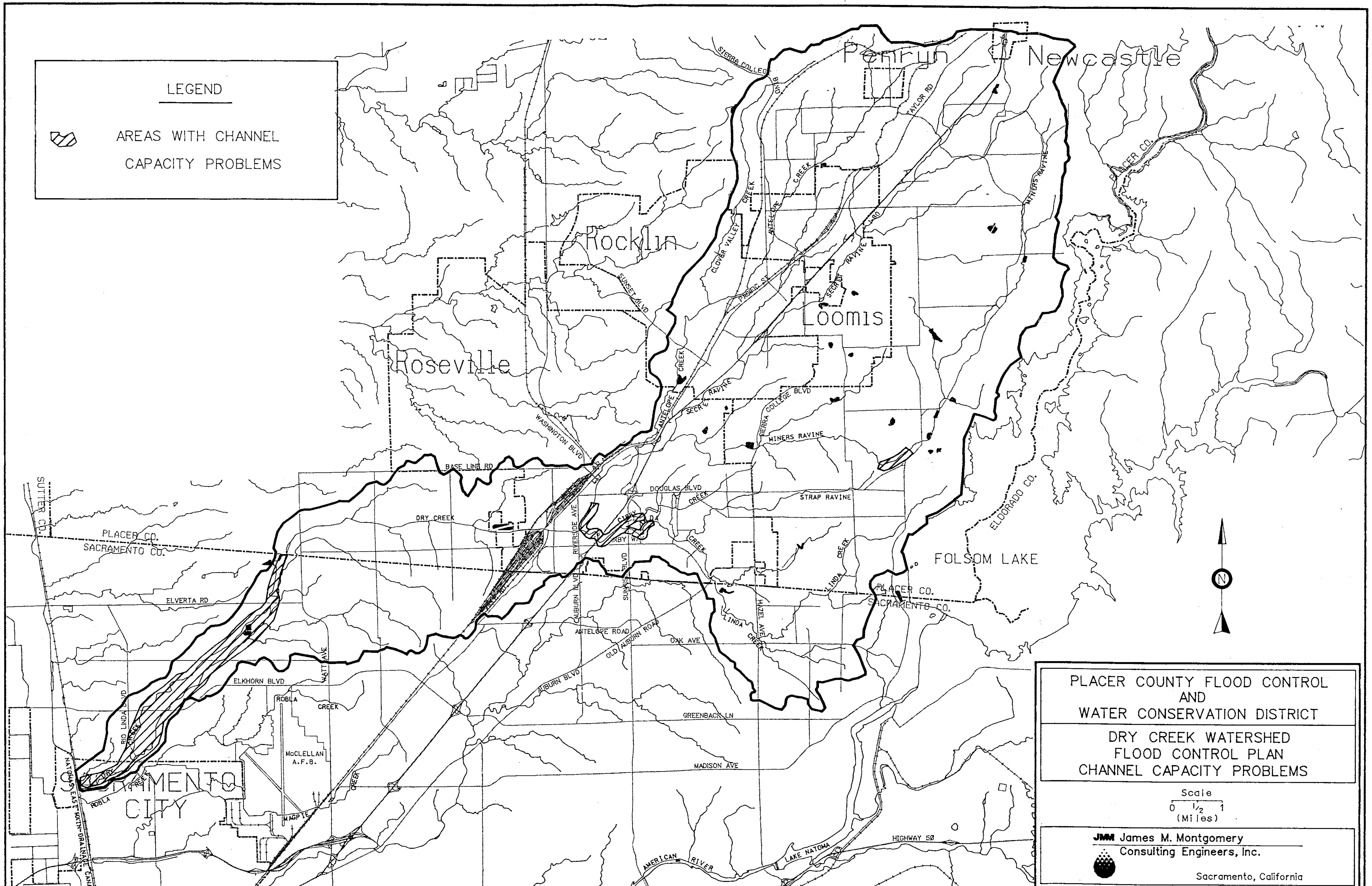
No.	Distance From Mouth (ft)	Location Description	Capacity	1986 Flood Damage	Overtopping Flow in cfs			
					100-yr 1989	100-yr Future	25-yr 1989	25-yr Future
	ANTELOPE CREEK							
123	1400	Harding Blvd.	New Bridge	Overtopped, New Bridge 1991				
124	2300	Atlantic Street	5000					
125	5000	County Dump Road						
126	9600	Highway 65	5000					
127	10300	Springview Drive	3000		176	587		
130	15800	Sunset Blvd.	3000		104	493		
134	23600	Midas Avenue	2270	Overtopped	60	410		
135	25700	Southern Pacific Railroad	5000					
136	26500	Yankee Hill Road	2234	Overtopped, damaged	69	418		
138	28900	Unnamed Road	500	Overtopped	1742	2087	1005	1254
139	31800	Delmar Avenue	600	Overtopped	1642	1987	905	1154
140	34300	Sierra College Blvd.	2300			229		
141	37000	King Road	1100	Overtopped	1037	1382	365	615
	ANTELOPE CR/CLARK TUNNEL RD TRIB.							
143	100	Barker Road	750		518	853	133	365
144	1300	Humphrey Road	900	Overtopped	255	637	34	318
148	7000	Colwell Road	240		571	934	359	630
149	10000	English Colony Way	430		329	722	90	340
150	12800	Clark Tunnel Road	150	Overtopped	147	365	68	232
	ANTELOPE CR/ROCKLIN CITY TRIB.							
152	2700	Taylor Road	290					
153	3800	Taylor Road	290					
154	4500	Sunset Blvd.	500					
	ANTELOPE CR./CLOVER VALLEY CR.							
156	400	Argonaut Avenue	1250					
157	2200	Footbridge and Weir	360		482	555	222	267
158	4300	Midas Avenue	1040	Overtopped				
159	4700	Abandoned Stone Bridge	1200					
160	5600	Unnamed Bridge	1010					
161	6500	Clover Valley Det. Pond	420					
162	7700	Creekwood Drive	560		257	322		45
163	12000	Rawhide Road	1650	Overtopped				
165	25600	Unnamed Road	200		222	319	107	178
166	28000	Sierra College Blvd	1000					
167	28500	English Colony Way	170		252	349	137	208
	ANTELOPE CREEK CONTINUED							
170	40600	Barker Road	450		320	369	106	142
171	42500	Citrus Colony Road	20		712	780	486	735
172	47900	English Colony Way	30		350	454	249	328
	ANTELOPE CR./HUMPHREY TRIB.							
174	1700	Sandy Road	30		225	293	155	206
175	3300	Mardell Lane	100		118	177	58	102
176	3700	Colwell Road	20		162	211	112	148
177	6300	English Colony Way	55		54	83	24	46
	MINERS RAVINE							
179	200	Harding Blvd.	8000	Overtopped, New 1991		479		
180	1500	Interstate 80	15000					
181	2800	Eureka Way	10000					
183	5300	Sunrise Avenue	10000					
185	9000	East Roseville Parkway	5000					
186	18200	Sierra College Blvd.	2500	Overtopped	1347	1965	77	473
188	18600	Cavitt & Stallman Road	2000	Overtopped	1241	1823	276	681

TABLE 3-1 (Continued)

No.	Distance From Mouth (ft)	Location Description	Capacity	1986 Flood Damage	Overtopping Flow in cfs 100-yr 1989	100-yr Future	25-yr 1989	25-yr Future
190	23400	Shadow Oaks Lane	400	Overtopped	2771	3345	1815	2219
191	28900	Barton Road	1200	Overtopped	1901	2471	947	1357
192	31300	Tall Pine Lane	900	Overtopped	2141	2703	1205	1610
193	33000	Carolinda Drive	800	Overtopped	2182	2735	1263	1662
194	34800	Itchy Acres Road	650	Overtopped	2286	2834	1379	1776
196	35500	Miners Ravine Road	1500	Overtopped	1409	1953	509	904
197	36800	Leibinger Lane	900	Overtopped	1981	2521	1089	1483
199	39700	Auburn Folsom Road	2000	Overtopped	766	1278		366
201	43000	Old Bridge		Abandoned				
203	44400	Auburn Folsom Road	1500		1194	1704	366	723
205	56000	Moss Lane	500		1968	2467	1210	1555
207	59900	Dick Cook Road	500	Overtopped	1287	1777	727	1025
208	61500	Auburn Folsom Road	600		1091	1554	581	873
209	62400	Placer Canyon Parkway	650		946	1381	483	769
210	67600	Horseshoe Bar Road	500		799	1145	390	642
211	71700	Auburn Folsom Road	400		608	904	330	555
212	73300	King Road	150		799	1084	544	760
213	79400	Penryn Rock Springs Rd.	100		177	276	99	175
214	80200	Newcastle Road	No Culvert					
	MINERS RAVINE/BOARDMAN TRIB.							
216	800	East Roseville Parkway	1000					
	MINERS RAV./CAVITT & STALLMAN TRIB.							
218	2400	Hidden Valley Place	110		456	545	398	500
219	3100	Baywood Road	150		387	471	327	423
220	3700	S Bar B Lane	110		398	478	336	425
221	4500	Kokula Lane	90		389	464	325	407
222	5100	Crestview Lane	140		311	381	244	320
223	9300	Barton Road	200		296	465	160	286
	MINERS RAVINE/LAKE TRIB. (MR21)							
225	200	Auburn Folsom Road	30		323	424	228	305
226	300	South Lake Circle	40		313	414	218	295
	SECRET RAVINE							
228	1400	East Roseville Parkway	10000					
231	17600	Rocklin Road	4800	Overtopped 2-3 feet				
232	23300	Sierra College Blvd.	4400					
233	28800	Private Road						
234	29200	Private Road						
235	30800	Brace Road	1800	Overtopped	1290	1849	231	581
236	32600	Horseshoe Bar Road	2500	Overtopped	588	1184		
239	38600	King Road	1250	Overtopped	1108	1627	330	715
241	40000	Penryn Road	1600	Damaged	737	1256		357
242	40500	Harris/Boulder Cr. Road	800		1531	2050	759	1155
244	43300	Boulder Creek Road	360		1601	2011	836	1257
245	48500	Brennans Road	100		1046	1269	631	1028
246	48900	Rock Springs Road	70		1048	1270	648	1043
247	50400	Meadow Lane	680		352	574		381
248	51300	Los Puentes Road	140		918	1254	503	887
249	55300	Newcastle Road	40		887	1257	626	903
250	57700	Powerhouse Road	45		604	863	421	615
	SECRET RAVINE/SUCKER RAVINE							
252	1000	China Garden Road	900		240	522		247
253	1200	Interstate 80	900		238	520		245
254	2200	Oakridge Street	1800					

TABLE 3-1 (Continued)

No.	Distance From Mouth (ft)	Location Description	Capacity	1986 Flood Damage	Overtopping Flow in cfs			
					100-yr 1989	100-yr Future	25-yr 1989	25-yr Future
255	2600	Lakeside Drive	650		507	806	85	482
256	3950	Rocklin Road	540		629	945	176	571
258	4700	Super Span	1200			269		
259	7450	Sierra Meadows Drive	1700					
260	10800	Dominguez Road	30		1035	1464	567	943
263	13400	Pacific Street	75		532	505	478	844
264	14800	Bankhead Road						
265	15200	Sierra College Blvd.	210		330	331	303	660
266	19000	Saunders Avenue	120		411	865	91	335
267	20200	King Road	240		301	774		215
	SECRET RAV./SUCKER RAV./LOOMIS TRIB.							
270	4400	Sierra College Blvd.	190		19	251		139
	SECRET RAVINE/AGUILAR RD. TRIB.							
272	700	Aguilar Road	250		299	468	279	640
273	2400	Foothill Road						
274	4100	El Don Road	130		361	497	346	694
275	4100	El Don Detention Pond	2000					
276	6100	Sierra College Blvd.	300		162	283	34	123
	SECRET RAVINE/LOOMIS TRIB.							
278	1200	Interstate 80	3000					
279	2800	Laird Street						
280	3600	King Road						
	SECRET RAVINE/KING ROAD TRIB.							
282	3900	Rancho Verde Road	130		1140	1265	613	1012
283	5400	Val Verde Road	100		319	405	203	268
284	6300	King Road	480					
	SECRET RAVINE/PENRYN TRIB.							
286	4700	Rock Springs Road	1600					
287	5600	East/West Forks Conf.						
	SECRET RAV./E. FORK PENRYN TRIB.							
289	900	Fairview Lane	200		28	119		35
290	3700	Gilardi Road	130					
	SECRET RAV./W. FORK PENRYN TRIB.							
292	200	Interstate 80	2000					
293	1400	Gilardi Road	180		387	844	236	577



LEGEND
AREAS WITH CHANNEL CAPACITY PROBLEMS
Penryn
Newcastle
Rocklin
Loomis
Roseville
SACRAMENTO
CITY
FOLSOM LAKE
PLACER CO.
SACRAMENTO CO.
SUTTER CO.
ELDORADO CO.
DRY CREEK
BASE LINE RD
ELVERTA RD
ELKHORN BLVD
WATT AVE
ROBLA CREEK
McCLELLAN A.F.B.
MAGPIE
RIO LINDA BLVD
NATOMAS EAST MAIN DRAINAGE CANAL
ANTELOPE ROAD
OLD AUBURN ROAD
OAK AVE
AUBURN BLVD
GREENBACK LN
MADISON AVE
AMERICAN RIVER
LAKE NATOMA
HIGHWAY 50
DOUGLAS BLVD
STRAP RAVINE
MINERS RAVINE
SECRET RAVINE
SIERRA COLLEGE BLVD
LINDA CREEK
HAZEL AVE
CLOVER VALLEY CREEK
ANTELOPE CREEK
SUNSET BLVD
WASHINGTON BLVD
RIVERSIDE AVE
TAYLOR RD
PACIFIC ST
PLACER COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT
DRY CREEK WATERSHED FLOOD CONTROL PLAN
CHANNEL CAPACITY PROBLEMS
Scale
0 1/2 1
(Miles)
JMM James M. Montgomery
Consulting Engineers, Inc.
Sacramento, California

FIGURE 3-1

increase will probably not be directly proportional to the increased flood flows because the length of the overflow section usually increases with increasing depth of flow over the roadway.

Structures. The areas where the increase in flood flows between 1989 and Future land use conditions causes additional problems do not change significantly from those already impacted by the 100-year flood with 1989 land use conditions. Additional homes may be impacted, but they will most probably be located near those that are at risk with 1989 land use conditions. Exact locations of impacted structures are very difficult to determine without using floodplain mapping techniques such as those used by FEMA in preparing flood insurance studies.

Erosion Potential

Except where roadway embankments were eroded by flood waters flowing over the roads during the February 1986 flood, the streams in the Dry Creek watershed have not shown a serious erosion potential in the past. Dense vegetation, in and along the majority of the channels and floodplains in the watershed, reduces flow velocities and erosion potential significantly. This slowing in flow velocity, in addition to the fact that flood flows are normally of fairly short duration, would seem to indicate that erosion of stream banks should not be a serious problem.

Erosion protection may be required, however, in areas where channel improvements are constructed because of the higher velocities that area incident with those improvements. Erosion protection will also be required in the stilling basin area downstream of the outlets from the regional detention basins. This erosion protection can take many forms but will usually be rock riprap, gabions, grassing, or some other type of channel lining.

CHAPTER 4
FLOOD MANAGEMENT OPTIONS AND ALTERNATIVES

In general, flood control approaches can be divided into two classes: structural and nonstructural. Structural approaches are those involving the traditional methods of capital improvement projects such as channels improvements, floodwalls, bridge and culvert replacement, regional detention basins, levees, etc. In contrast, nonstructural approaches attempt to minimize flood damage and losses through a variety of planning and administrative procedures that are less capital intensive. Included in this category are floodplain management, on-site detention, and flood warning systems.

The various structural and nonstructural alternatives that were considered for inclusion in the Dry Creek Watershed Flood Control Plan, along with evaluation criteria, are discussed in the following sections. The evaluation sections will include a discussion of the environmental impacts of the proposed alternatives.

STRUCTURAL ALTERNATIVES

Only three types of structural alternatives were actively considered as part of the Flood Control Plan; bridge and culvert replacements, regional detention basins, and channel improvements, levees, and floodwalls. Each of these types of structural alternatives is discussed in the following sections.

Regional Detention Basins

Regional detention basins are the only available alternative that will reduce existing flood flows in the watershed. These detention basins typically consist of a 15 to 35 foot high dam, capable of storing 50 to 500 acre-feet of stormwater, on one of the large tributaries in the watershed. The flow-through outlet in the dam is designed to reduce flood flows by restricting the peak flow that will pass through the outlet. The flood flows that exceed the capacity of the outlet will be stored in the basin and released over a period of time after the peak of the storm has passed.

A regional detention basin can be designed to reduce flood flows for any given flood return period, but normally the basin will be designed to control 25- to 100-year flood flows. The regional detention basins studied as part of the Dry Creek Watershed Flood Control Plan were designed specifically to reduce 100-year flood flows. However, it will be possible, during the feasibility studies for each of the basins, to study the possibility of designing them to also control other floods.

In all, 25 detention basin sites were investigated throughout the watershed. Many of the sites were judged to be unrealizable due to existing development, proposed development, difficulty or cost of obtaining the land, and lack of sufficient available storage capacity at the site. Those sites finally selected as part of the flood control plan met the criteria of efficient reduction of flood flows, both locally and regionally, and cost effectiveness based on detention basin cost versus regional flow reduction.

Selection Criteria. The first step in the selection process for the regional detention basin sites was determining the availability of suitable sites on major streams. A total of 25 regional detention basin sites were initially identified from topographic maps, aerial photographs, and visits to the watershed.

The second step in the screening process was to determine if the land was currently undeveloped and whether the topography and layout of the site were suitable to support a regional detention basin. At that point a number of potential sites were removed from consideration due either to unavailability or unsuitability of the site.

The regional detention basins for the Dry Creek watershed are needed to mitigate both existing flooding problems and the increase in flood flows due to upstream development. Because they are to solve existing problems, it was decided that flood storage at each detention basin site under consideration would be maximized in the screening process. The maximum area and storage were determined for each site and then they were simulated using the HEC-1 model of the watershed in order to provide a basis for comparison.

Two criteria were used to select the best regional detention basin sites. Efficiency, defined as the ratio of the regional flow reduction due to the detention basin to the area inundated at the site was the first criteria, and cost per cfs, defined as the regional flow reduction divided by the total cost of construction and land acquisition for the detention basin, was the second. The application of the selection criteria to the available regional detention basin sites is discussed below and is tabulated in Table 4-1.

Evaluation Of Existing Detention. Detention basins currently existing in the Dry Creek watershed are located at stream crossing numbers 66, 161, 164, and 274, indicated in Table 2-7 and on Figures 1-7a to 1-7e. Operational data for each of these detention basins was collected during the watershed inspection conducted as part of this study. Each of the existing basins was simulated in the watershed model. As a rule, these detention basins are not providing a level of protection consistent with the requirements of this plan. Most appear to be designed as local detention basins to reduce up to 10-year flood peaks. One, the Sierra Gardens detention basin on Cirby Creek, was found to be designed correctly and was functioning up to accepted criteria for a 100-year storm. Many of the other basins were too small or had storage capacities that were too small and outlet capacities that were too large to reduce the 100-year flood peak significantly.

Evaluation of Proposed Regional Detention. As described above, a careful study of the Dry Creek watershed located 25 potential sites for regional detention basins. Of these 25 sites, nine were found to be infeasible due either to existing or approved development at that location, high potential land costs, large number of land owners, marginal added benefits from detention, and siting problems due to the topography. Figure 5-1 is a map that includes the location of all the proposed regional detention sites. Table 4-1 presents all of the detention basin sites with notations for those for which further study was not warranted.

The maximum available area and corresponding dam height, allowing for adequate freeboard, were determined for each site. This was based on the assumption that the size of each regional detention basin would be made as big as the site would allow to provide the maximum flood control benefit. Using standard design specifications and state dam safety regulations, detention dams, outlet works, and spillways were designed for each of the sites. The spillways were designed to pass the Probable Maximum Flood without endangering the detention dam itself.

Once the detention basin configurations were known, flood control operation of each detention basin was studied using the HEC-1 computer model of the watershed. The maximum flood control storage at the site and flow reduction, both local (i.e., just downstream of the detention dam) and regional (at Vernon Street in Roseville), were determined from the model. The efficiency for each basin, calculated as described in the section on evaluation criteria, is given in Table 4-1. Higher numbers indicate the most hydrologically efficient regional detention basins. Construction cost estimates, including land

TABLE 4-1

EVALUATION OF PROPOSED REGIONAL DETENTION BASINS

Det. Basin No.	Basin Location	Inun-dated Area (acres)	Dam Height (ft)	Max. Storage (ac-ft)	Local Flow Reduction (cfs)	Flow Reduction at Vernon (cfs)	Efficiency at Vernon Street (cfs/acre)	Dam Cost ($)	Assumed Land Cost @$65k/acre ($)	Total Cost ($)	Cost per cfs Flow Reduction ($/cfs)
1*	Miners Ravine below Sierra College Boule	74	42	811	1806	1607	21.72	$1,416,911	$0	$1,416,911	$882
2	Miners Ravine Trib. Sec.23 T11N R7E	Site not feasible for acquisition due to large number of property owners.									
3	Secret Rav. US of confluence with Miners	No feasible site due to bridges and highways near site.									
4*	Secret Ravine US of Rocklin Rd nr. Sierra	27	30	189	348	444	16.44	$1,124,017	$0	$1,124,017	$2,532
5	Secret Rav. Trib. nr. Horseshoe Bar Road	45	15	426	57	157	3.49	$312,257	$3,217,500	$3,529,757	$22,483
6*	Antelope Creek at Atlantic Street	28	15	87	226	261	9.32	$530,395	$0	$530,395	$2,032
7*	Antelope Creek DS of Delmar Avenue	70	30	410	1417	766	10.94	$1,283,317	$5,005,000	$6,288,317	$8,209
8	Clover Valley Cr. in Sec.5 T11N R7E	37	20	229	353	277	7.49	$407,325	$2,645,500	$3,052,825	$11,021
9*	Strap Ravine at McLaren Drive in Maidu P	19	18	59	195	96	5.05	$256,924	$0	$256,924	$2,676
10	Linda Cr. US of Sacramento County line	Site not available due to prior development.									
11	Linda Cr. Trib. US of Sierra College Blvd.	25	15	99	135	225	9.00	$545,620	$1,787,500	$2,333,120	$10,369
12*	Linda Cr. Orangevale Trib. at Oak Avenue	25	12	70	294	189	7.56	$168,583	$0	$168,583	$892
13	Dry Creek US of Watt Avenue	Natural detention of more than 600 acre-feet already exists due to undersized Watt Avenue bridge.									
14	Antelope Creek near Taylor Road	No on-channel site available at this location.									
15	Miners Rav. Cavitt Stallman Trib. US of c	18	20	99	209	120	6.67	$451,503	$1,287,000	$1,738,503	$14,488
15A	Miners Rav. Cavitt Stallman Trib. DS of B	51	15	207	363	305	5.98	$370,934	$3,646,500	$4,017,434	$13,172
16*	Secret Ravine US of Sierra College Blvd.	20	20	148	267	316	15.80	$938,354	$1,430,000	$2,368,354	$7,495
17	Secret Ravine near Boulder Creek Road	18	20	139	471	12	0.67	$460,775	$1,287,000	$1,747,775	$145,648
18	Linda Creek DS of Indian Creek Drive	Site not available due to prior development.									
19	Antelope Creek US of Colwell Road	Site not available due to high acquisition cost and existing single family homes.									
20	Dry Creek near Walerga	Natural detention of more than 790 acre-feet already exists due to undersized Walerga bridge.									
21	Miners Rav. US of Cavitt Stallman Trib.	36	20	169	364	308	8.56	$873,860	$2,574,000	$3,447,860	$11,194
22	Miners Rav. DS of Lake Tributary conflue	Site not available due to prior development.									
23	Sucker Rav. US of confluence with Secret	57	10	88	261	249	4.37	$215,365	$4,075,500	$4,290,865	$17,232
24	Miners Rav. Boardman Trib. US of conflu	14	35	159	99	63	4.50	$456,283	$1,001,000	$1,457,283	$23,131

* Selected Regional Detention Basin Sites

acquisition costs, were developed and divided by the regional flow reduction, as shown in Table 4-1, to get the cost per cfs of flow reduction.

Each of the proposed regional detention basins was ranked according to the criteria of efficiency and cost per cfs reduction. On the basis of the rankings, seven regional detention basins (1, 4, 6, 7, 9, 12, and 16) were selected for inclusion in the Dry Creek Watershed Flood Control Plan. The regional detention basins are distributed in all of the major tributaries and will provide nearly 4,000 cfs reduction in future peak flows at Vernon Street in Roseville. Several other regional detention basin sites that are fairly close in the rankings to the seven picked would make good alternate sites if any of the primary sites are unavailable.

The regional detention basin analysis was concerned only with the operation of the detention basins in a 100-year flood (the design flood). This does not mean that the regional detention basins will not be effective for storms with shorter return periods, such as the 10- and 25-year storms. If the detention basin outlet works are designed properly with staged outlets, they will be able to provide control of the 10-, 25-, and 100-year flood flows in the stream. It is important to note, however, that the provision of protection for the 10- and 25-year storms will decrease the storage available for detention of the 100-year flood.

Environmental Impacts of Detention The environmental impacts of detention will largely result from the construction of the detention basins. Construction of the regional detention facilities will require stripping of the dam foundation, excavation of fill material for the dam, and construction of the embankment, emergency spillway, and outlet works.

Potential environmental impacts of construction may include:

- Erosion of unvegetated areas;
- Removal of trees and shrubs as required to strip the foundation of the dam, to construct the emergency spillway, and to excavate the embankment material;
- Displacement of wildlife during the construction activities;
- Displacement of the fish population and destruction of possible spawning beds at the dam site; and
- Short-term sedimentation in the stream during construction of the outlet works.

Environmental impacts of the regional detention facilities will be small after conclusion of the construction process. The outlet works will be designed for flow-through operation at low flows and it is believed that they will not act as a barrier to fish or wildlife. Some amount of increased erosion may occur downstream of the detention basins due to the longer sustained flows.

Bridge and Culvert Replacement

Bridge and culvert replacement is required when the capacity of a bridge or culvert is limited and as a result causes floodwaters to either backup into adjacent structures, or overtop the bridge or culvert. Maintenance of the existing flood storage in the floodplain was an important aspect that was considered when determining the required size and configuration of replacement bridges and culverts. Removal of existing flood storage upstream of culverts could increase flood flows downstream of the area where the storage is removed. For this reason, the replacement bridges and culverts were designed conceptually so as not to be overtopped by the 100-year flood flows while at the same time maintaining as much of the existing flood storage above the crossing as possible. This design concept will keep the impacts of the culvert or bridge improvement to a minimum, while at the same time solving the problems caused by inadequate bridge or culvert capacity.

Selection Criteria. Because of the large number (over 130) of inadequate bridges and culverts in the watershed (see Table 3-1), it was not possible to include all of them in this plan. Therefore, each jurisdiction examined the complete list of inadequate crossings and prepared a list of those that had the highest priority for replacement. Some of the factors considered in determining the bridges and culverts to be placed on the list included:

- Potential for injury or loss of life
- Potential for property damage or damage to the bridge or culvert
- Emergency access to isolated areas
- Inconvenience caused by road closure
- Privately owned structures were excluded

A total of 42 bridges and culvert were selected to be replaced as part of the Dry Creek Watershed Flood Control Plan and are listed in Table 4-2.

Evaluation Of Bridge and Culvert Replacement. The required capacity for each of the replacements was taken from the peak flow tabulation in Table 2-7 and a replacement or addition was designed for each of the locations. Table 4-2 indicates the current size of the crossing and the suggested size after replacement. A major design criterion used in determining the replacement sizes for the bridges and culverts was that the bridge or culvert pass the peak flow with no freeboard. These design criteria will result in the smallest possible reduction in storage upstream of the bridge or culvert, while at the same time providing adequate capacity to pass the 100-year peak flows. Maintenance of existing upstream storage capacity as culverts are improved will help prevent increases in downstream flow that would occur if the storage was lost. As was discussed previously, the natural storage in the watershed is an important factor in reducing the peak runoff from a given storm event.

Environmental Impacts of Bridge and Culvert Replacement Environmental impacts of bridge and culvert replacement will occur as a result of the construction process. These impacts may include:

- Erosion of exposed areas;

- Displacement of wildlife during the construction activities; and

- Short-term sedimentation in the stream during construction.

The environmental impacts of the bridge or culvert after construction will be no different from those of the bridge or culvert being replaced or improved.

Channel Improvements, Levees, and Floodwalls

There exist areas in the Dry Creek watershed where stream channels and floodplains have insufficient capacity to pass the 100-year flood flows without impacting existing structures. Channel improvements, levees, and/or floodwalls may be the most practical structural measures to protect those existing structures, short of actually moving them out of the floodplain.

The Placer County Stormwater Management Manual contains specific instructions on when channel improvements are appropriate. It states that channel improvements involving the straightening and enlargement of the stream channel are not permitted except as necessary to protect existing structures or improvements from flood damages. In conjunction with this work, the channel is also usually treated in some manner to insure that the improved channel

TABLE 4-2

BRIDGE AND CULVERT REPLACEMENTS

Item No.	Stream Cross. No.	Description	Existing Type	Existing Size	Replacement Type	Replacement Size (ft)
1	14	Dry Creek @ Walerga Road	Bridge	12 x 126	Bridge	add 12 x 28
2	16	Dry Creek @ Cook Riolo Road	Bridge	14 x 200	Bridge	add 14 x 50
3	18	Dry Creek @ Atkinson Blvd	Bridge	21 x 165	Bridge	excavate chan.
4	22	Dry Creek @ Riverside Avenue	Bridge	13.5 x 80	Bridge	add 13.5 x 95
5	24	Dry Creek @ Darling Way	Bridge	15.5 x 110	Bridge	add 15.5 x 33
6	28	Dry Creek @ Folsom Road	Bridge	15 x 112	Bridge	add 15 x 52
7	41	Dry Creek County Line Trib. @ Watt Ave.	CMPA	1 - 4 x 5	CMPA	3 - 5.8 x 8.2
8	44	Dry Creek DC65 Trib. @ Walerga Road	CMP	1 - 4	CMPA	3 - 4.7 x 6.9
9	50	Cirby Creek @ Sunrise Boulevard	CMP	1-7	CMPA	1 - 6.9 x 10.7
10	52	Cirby Creek @ Oak Ridge Drive	CMP	3 - 5	CMPA	1 - 6.6 x 9.8
11	54	Cirby Creek @ Loretto Drive	CMP	3-5.5	CMPA	3 - 5.8 x 8.2
12	56	Cirby Creek @ Sierra Gardens Drive	CMP	3 - 5	CMPA	1 - 6.6 x 9.8
13	68	Linda Creek @ Sunrise Avenue	Bridge	14 x 89	Bridge	add 14 x 50
14	90	Linda Creek @ Barton Road	CMPA	1 - 3.7 x 6	CMPA	4 - 5.9 x 8.6
15	94	Linda Creek @ Auburn-Folsom Road	CMPA	1 - 4.3 x 6	CMPA	1 - 5.6 x 7.9
16	100	Strap Ravine @ Sierra College Blvd.	Bridge	4 x 16	CMPA	3 - 5.8 x 8
17	105	Linda Cr. Treelake Trib. @ Sierra Coll. Blvd.	CMPA	1 - 5.5 x 11	CMPA	2 - 6.4 x 9.5
18	123	Antelope Creek @ Harding Boulevard	Bridge	9.5 x 49	Bridge	under const.
19	148	Antelope Creek/Clark Tunnel Rd Trib. @ Colwe	CMPA	2 - 3.8 x 6	CMPA	3 - 4.6 x 6.1
20	150	Antelope Cr/Clark Tunnel Rd Trib.@ Clark Tun	CMP	1 - 4.5	CMP	2 - 5
21	167	Clover Valley Creek @ English Colony Rd.	CP	1 - 4	CMPA	1 - 4.8 x 6.9
22	171	Antelope Creek @ Citrus Colony Road	CMP	1 - 2.5	Bridge	1 - 4.6 x 40
23	172	Antelope Creek @ English Colony Road	CMP	1 - 3	Bridge	1 - 5 x 20
24	176	Antelope Cr. Humphrey Trib. @ Colwell Rd.	CMP	1 - 4.5	CMP	2 - 5
25	186	Miners Ravine @ Sierra College Blvd.	RCB	3 - 7.9 x 11	RCB	dd 2 - 7.9 x 12.
26	191	Miners Ravine @ Barton Road	Bridge	5.5 x 29	Bridge	8 x 60
27	199	Miners Ravine @ Auburn-Folsom Road	Bridge	7.3 x 23	Bridge	add 7.3 x 15
28	203	Miners Ravine @ Auburn-Folsom Road	Bridge	10 x 22	Bridge	add 10 x 25
29	207	Miners Ravine @ Dick Cook Road	Bridge	5 x 20	RCB	5 - 7 x 13
30	208	Miners Ravine @ Auburn-Folsom Road	CMP	2 - 6	CMPA	3 - 6.2 x 9.3
31	210	Miners Ravine @ Horseshoe Bar Road	Bridge	3.5 x 20	RCB	5 - 5 x 9
32	212	Miners Ravine @ King Road	CMPA	1 - 4 x 5	CMPA	3 - 5.9 x 8.6
33	223	Miners R. Cavitt-Stallman Trib. @ Barton Rd.	CMPA	1 - 5.5 x 7	CMPA	2 - 5.2 x 7.2
34	225	Miners Ravine Lake @ Auburn-Folsom Rd.	CMPA	3 - 1.6 x 4	CMPA	4 - 4.2 x 5.5
35	235	Secret Ravine @ Brace Road	Bridge	10 x 54	Bridge	add 10 x 54
36	245	Secret Ravine @ Brennans Road	CMPA	1 - 3.9 x 6	Bridge	6.5 x 40
37	246	Secret Ravine @ Rock Springs Road	CMPA	1 - 4.1 x 6	Bridge	6.5 x 40
38	249	Secret Ravine @ Newcastle Road	CMP	1 - 3.5	Bridge	7 x 45
39	250	Secret Ravine @ Powerhouse Road	CMP	1 - 3	Bridge	6 x 25
40	256	Sucker Ravine @ Rocklin Road	CMP & RCB	1 - 5 & 1 - 5 x 9	CMPA	2 - 6.2 x 9.3
41	267	Secret Ravine @ King Road	CMP	1 - 6	CMPA	3 - 5.6 x 7.9
42	293	Secret R. West Fork Penryn Trib. @ Gilardi	Bridge	1.8 x 15	Bridge	5.2 x 30

will not erode. Treatment can include lining of the channel with rock riprap, gabions, concrete, or grasses. In some instances where the required additional capacity is relatively small, it may not be necessary to enlarge or straighten the channel. In those cases it may be sufficient to simply maintain the channel and remove obstructions.

Where it is not possible to construct channel improvements, or where channel improvements alone will not provide adequate protection, it is also necessary to build levees or floodwalls. A levee is an earthen berm built alongside the stream channel, preventing flood flows from overflowing out into portions of the floodplain containing buildings that are being protected. Floodwalls are typically constructed out of concrete or concrete block and perform the same function as levees, but are used where there is not enough room to construct a levee. Levees are required in place of floodwalls where the height of the protection must exceed about five feet.

Downstream impacts of channel improvement and levee projects may include increased erosion due to higher velocities coming out of the reach, and higher flood peaks caused by the reduction of storage volume in the improved reach of the channel. It is important to conduct detailed studies prior to construction of channel improvements or levees so that the exact nature of these impacts may be determined.

Selection Criteria. Environmental considerations make channel improvements, such as channel widening or clearing, the least desirable of the possible structural flood control alternatives. Channel widening and clearing can increase the flooding and erosion downstream of the channel improvement as described earlier. Channel improvements are used when no other feasible alternatives are available to solve the flooding problems at a particular location in the watershed. Levees and floodwalls may be used in conjunction with the channel improvements to reduce the amount of channel improvement that has to take place to obtain a given level of protection.

Locations in the watershed where the existing channel capacity is not sufficient to pass the 100-year flood, and the floodplain has been encroached upon are candidates for channel improvements and floodwalls. If, in addition, there are no upstream locations for detention facilities adequate to reduce the flood peaks to acceptable levels, then channel improvements may be the only feasible solution to the flooding problem.

Evaluation of Channel Improvements, Levees, and Floodwalls Channel improvement, levees and floodwalls were evaluated for three locations in the Dry Creek watershed: Cirby, Linda, and Dry Creeks in Roseville, Dry Creek in Rio Linda, and an area along Miners Ravine in the area of Joe Rodgers Road in Placer County. The three locations are shown as shaded areas on Figure 5-1.

City of Roseville Channel Improvement Project. Flood damages occur at various locations along Cirby, Linda, and Dry Creeks in the City of Roseville for floods ranging from 10-years on up. Many of these locations have been flooded 2-3 times in the last ten years. The Corps of Engineers was originally studying these locations for a flood control project, but since Corps support was withdrawn in 1990, the City has determined to proceed with and fund the project without Corps assistance.

The regional detention basins proposed as part of this study, in conjunction with local detention for new development, will reduce the flows in Dry Creek as it leaves Roseville by nearly 30 percent. It may therefore be economically justified to use the regional detention basins to offset some of the planned channel and levee improvements through the City of Roseville. It should be noted that because of the distribution of the regional basins the flow reductions are not the same percentage on each of the major tributaries and some portions of the planned project will not be greatly affected by the regional detention basins.

SAFCA, Rio Linda Channel Improvement and Levee Project. The Sacramento Area Flood Control Agency (SAFCA) is currently planning channel improvements and the raising of levees on Dry Creek beginning at the Sacramento County line and ending at the Natomas East Main Drainage Canal. The purpose of these improvements is to reduce the flooding that presently occurs as a result of storms with recurrence intervals as short as two years. The improvements are being designed to protect the Rio Linda area from the 200-year flood flows developed as part of this study.

Regional detention basins will play a big role in the reduction of future flooding in the Rio Linda area of Dry Creek. The reach of Dry Creek between the City of Roseville and the Natomas East Main Drainage Canal will realize the full benefit of all of the regional and local detention basins in the watershed. Future peak flows passing through this reach of Dry Creek will be reduced by over 30 percent due to the action of the regional and local detention basins. This large reduction should be taken into account during the design of the improvements proposed by SAFCA.

Miners Ravine, Joe Rodgers Road Project Miners Ravine in the vicinity of Joe Rodgers Road, specifically, between a point 500 feet above Leibinger Lane to a point 500 feet below Itchy Acres Road, is identified as a flood-prone area due to inadequate channel, floodplain, and bridge capacity. Damages as a result of the 1986 flood included one home completely destroyed and many others less severely damaged. More than 40 homes in the area would be affected by a 100-year flood on Miners Ravine

Because the flooding problems at this location are the result of inadequate channel capacity, it may be necessary to solve them through channel improvements. The channel improvements for this project would include excavation and widening of the existing channel to increase the capacity of the channel. The excavation will be roughly trapezoidal in section, with a bottom width of 20 feet and side slopes of 3:1. A small low-flow channel meandering down the center will also be excavated during construction. This low-flow channel will provide suitable habitat for fishes and other aquatic animals during the dry months of summer and fall when the flow in Miners Ravine is very low. The size of the low-flow channel will concentrate these low flows into more habitable pools and streams. The excavated channel will be unlined, but the side slopes can be hydroseeded to provide erosion protection for the banks.

The culverts carrying Leibinger Lane across Miners Ravine cannot pass the 100-year flood for either the 1989 or Future conditions. The resulting obstruction to flow causes the flows in Miners Ravine to flow farther out onto the floodplain to the south than would otherwise happen. To remove this problem, the culverts at Leibinger lane will be replaced with CMPA culverts of sufficient size to the 100-year flood. The bridges at both Miners Ravine Road and Itchy Acres Roads are also inadequate to pass the 100-year flood. However, the excess flows simply pass over the top of these two bridges without causing any additional damage. It would be prohibitively costly to replace these bridges with structures that were not overtopped in the 100-year flood and their replacement was not included as part of this project.

Even with the proposed channel improvements and the new bridge at Leibinger Lane, numerous homes and other structures in the floodplain to the south of Miners Ravine would still be in jeopardy during a 100-year flood. A floodwall will be constructed on the south bank of Miners Ravine to protect those homes and structures. The floodwall envisioned would be constructed of concrete block and would be three to four feet high in order to provide 100-year flood protection.

Some reduction of the project size, as a result of the beneficial effects of upstream local detention, may be justified during the design phase of the project. None of the regional detention basins are located upstream of the project and thus no benefits will be realized from regional detention.

Environmental Impacts of Channel Improvements, Levees, and Floodwalls
Construction of channel improvements will have the most environmental impacts of any of the structural alternatives proposed as a part of this plan. Potential impacts to fish and riparian wildlife and vegetation are magnified due to the fact that the construction will be occurring in the stream channel for hundreds of feet. The potential construction impacts include:

- Erosion of unvegetated areas;
- Removal of trees and shrubs as required to construct the new stream channel;
- Displacement of wildlife during the construction activities;
- Displacement of the fish population and destruction of possible spawning beds along the channel improvement reach; and
- Short-term sedimentation in the stream during construction.

Post-construction impacts of the channel improvement will be mitigated by revegetation of the overbank areas and by provision of a meandering low-flow channel. This low-flow channel will provide pools and riffles for fish and riparian wildlife.

Construction impacts of levees or floodwalls may include:

- Erosion of unvegetated areas;
- Displacement of wildlife; and
- Removal of ground cover, trees, and shrubs along the levee or floodwall alignment.

NONSTRUCTURAL ALTERNATIVES

Local or On-site Stormwater Detention

Many rapidly growing communities have found that future drainage problems can be minimized by requiring new developments to provide on-site detention of stormwater so that the post-development runoff for specified design storms does not exceed the pre-development runoff for the same storms. Although this concept has been embraced by most of the jurisdictions in the Dry Creek watershed, implementation in the past has not been as successful as hoped.

The definition of local, or on-site detention is based on the size of the detention basin, the extent of the area it serves, and the design criteria used in its design. Local detention basins are typically designed to serve one or two subdivisions by storing excess stormwater flows before they leave the site.

Local or on-site detention if designed correctly will always be able to reduce the local, post-development flood flows downstream of the basin to pre-development levels. However, even though the local detention basins maintain the peak runoff from a developed area at the pre-development level, the peak flow is sustained for a longer period of time as the local detention basin releases the stormwater it has in storage. Without local detention, flood peaks from subbasins lower in the watershed would have receded before the arrival of all the upstream flood flows. With local detention however, the peak flows are maintained for a longer period of time than under natural conditions and these flows will begin to overlap at downstream points in the basin. The cumulative effect of these overlapping releases from all of the local detention basins in the watershed will reduce the effective flow reduction at downstream points.

Floodplain Management

Floodplain management in the Dry Creek watershed involves two different aspects. The first is based on controlling building in the floodplain and the second is based on controlling the changes (other than buildings) that are made in the floodplain.

Naturally, before it is possible to implement any floodplain management programs it will first be necessary to accurately map the floodplain. Ongoing floodplain mapping and remapping are an integral part of the Dry Creek Watershed Flood Control Plan

Controlling building in the floodplain is based on the assumption that it is better to keep people away from the water rather than keeping the water away from the people. Specific strategies can include establishment of designated floodplains and floodways within which new construction would be regulated or prevented (e.g., the National Flood Insurance Program); purchase of flood-prone land for use as parks or open space; and relocation of chronically flooded structures out of the floodplain. These strategies are primarily applicable to areas where development has not already occurred or been approved in the floodplain.

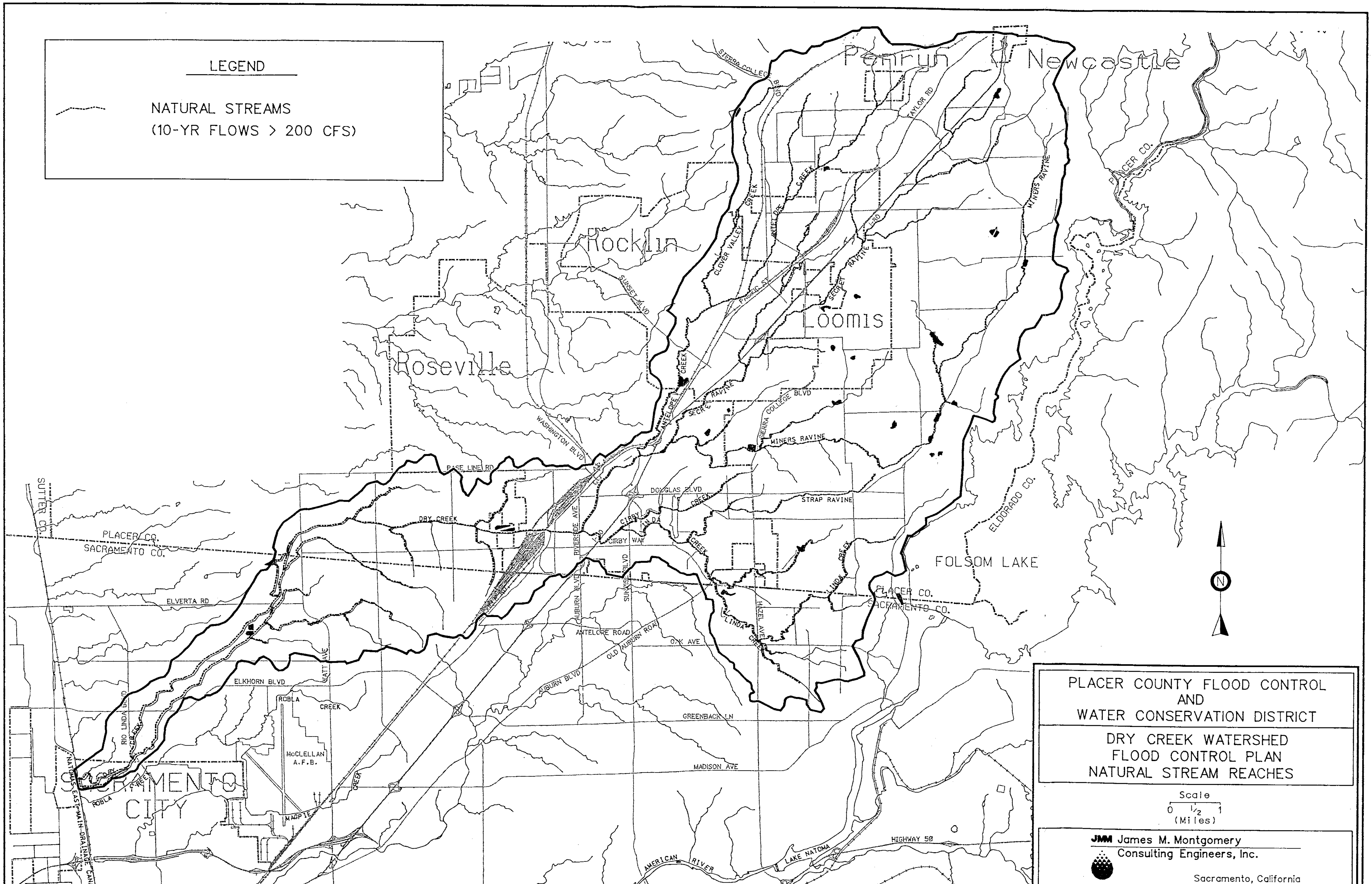
The second element of floodplain management is involved with controlling what changes are made to the stream channels and floodplains. One of the basic guidelines included in many of the general plans in the watershed is that no floodplain clearing or channel improvements will be allowed along any stream. Especially singled out are streams that carry 10-year flows greater than 200 cfs as shown on Figure 4-1. These streams are designated as natural streams and are to be open channels and are to remain in their natural state as much as possible.

Restricting the clearing of floodplains in the Dry Creek watershed will have a significant impact on the severity of flooding that occurs throughout the watershed. As discussed in Chapter 2, computer models developed as part of this study have shown that any clearing of existing vegetation in channels and floodplains in the watershed will result in an increase in flood flows.

Implementation of floodplain management solutions requires the ability to regulate or influence land use through zoning or other measures. In the Dry Creek Watershed this ability belongs to Placer and Sacramento Counties, Roseville, Rocklin, and Loomis, rather than with the Placer County Flood Control and Water Conservation District. In order for floodplain management to be effective, the various jurisdictions in the watershed must cooperate with the Flood Control District to implement the proposed solutions.

Flood Warning System

Flood warning systems can be especially effective in areas where some property damage can be tolerated as long as residents and personal property can be evacuated prior to flooding. Evacuation is only possible when there is adequate time to forecast storm activity, predict runoff, disseminate information, and move residents prior to the beginning of the flood. Because of the large size of the Dry Creek watershed, flood warning can be very effective in preventing endangerment and/or loss of life.



LEGEND
NATURAL STREAMS
(10-YR FLOWS > 200 CFS)
Penryn
Newcastle
Rocklin
Loomis
Roseville
SACRAMENTO CITY
FOLSOM LAKE
PLACER CO.
SACRAMENTO CO.
SUTTER CO.
ELDORADO CO.
DRY CREEK
ANTELOPE CREEK
CLOVER VALLEY CREEK
SECRET RAVINE
MINERS RAVINE
STRAP RAVINE
LINDA CREEK
CIRBY WAY
ROBLA CREEK
BASE LINE RD
DOUGLAS BLVD
ELVERTA RD
ELKHORN BLVD
ANTELOPE ROAD
OLD AUBURN ROAD
AUBURN BLVD
OAK AVE
GREENBACK LN
MADISON AVE
HIGHWAY 50
AMERICAN RIVER
LAKE NATOMA
McCLELLAN A.F.B.
N
PLACER COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT
DRY CREEK WATERSHED FLOOD CONTROL PLAN NATURAL STREAM REACHES
Scale
0 1/2 1
(Miles)
JMM James M. Montgomery
Consulting Engineers, Inc.
Sacramento, California

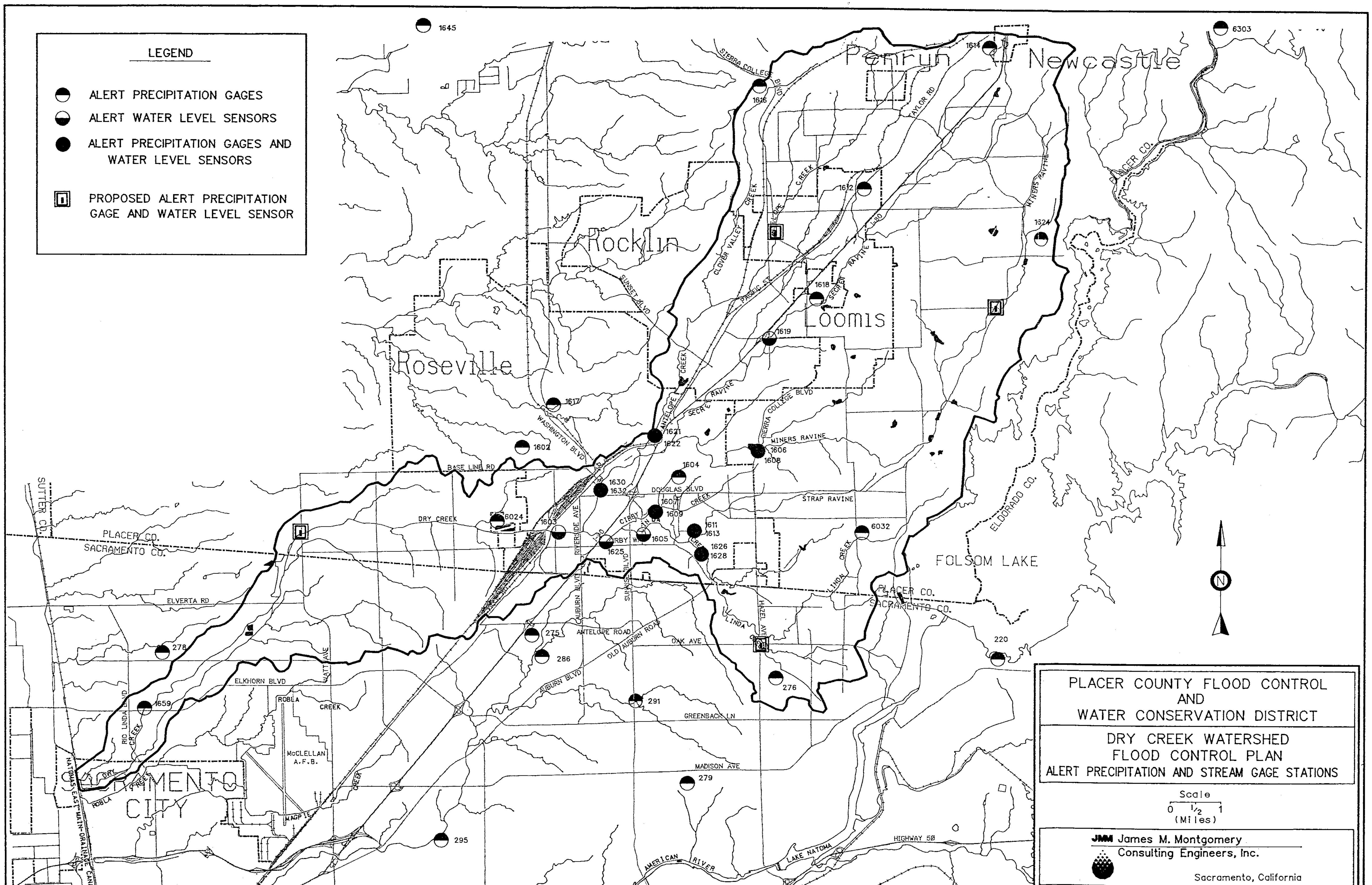
FIGURE 4-1

Flood warning systems are used to alert local emergency operations centers, and fire and police departments so that they can assist in the evacuation efforts. Another important function of a flood warning system is to provide a record of what happened during the storm event. This record can be used in further calibration of the rainfall/runoff model of the basin developed as part of the Dry Creek Watershed Flood Control Plan, and can also be used in planning future flood response activities.

Flood warning accuracy and lead time increase as the size of the basin being served increases. This means that residents living in small tributary subbasins would probably not receive sufficient warning time to protect them from flooding on that small tributary. Flooding along the major streams in the watershed can be predicted in a timely manner based on upstream flows and rainfall. For example, flood peaks occur in the upper reaches of Miners and Secret Ravines more than five hours before the peaks occur at Vernon Street in Roseville.

The National Weather Service and the California Department of Water Resources jointly coordinate a radio telemetered system called ALERT. ALERT is made up of precipitation gages, water level sensors, and weather stations that are owned and operated by local jurisdictions. Names and ownership of the existing ALERT gages in or near the Dry Creek watershed are indicated in Table 4-3 and the locations of the gages are shown on Figure 4-2. The City of Roseville currently owns and maintains most of the ALERT system for the Dry Creek watershed upstream of Roseville. Water level sensors are shown only for locations within Dry Creek watershed. All precipitation gages within the limits of the map are shown.

The ALERT systems consist of remote stations in the watershed, linked using line-of-sight radio telemetry to communicate with one or more base stations. The remote sites consist of an enclosure containing a water level sensor and/or a tipping bucket precipitation gage and radio telemetry equipment. Base stations have a receiver and decoder that is connected to a PC which manages the data from the remote stations. Software is available for the base station that will allow it to predict streamflows based on rainfall and measured stream water levels.


LEGEND
ALERT PRECIPITATION GAGES
ALERT WATER LEVEL SENSORS
ALERT PRECIPITATION GAGES AND WATER LEVEL SENSORS
PROPOSED ALERT PRECIPITATION GAGE AND WATER LEVEL SENSOR
Penryn
Newcastle
Rocklin
Loomis
Roseville
SACRAMENTO CITY
FOLSOM LAKE
PLACER CO.
SACRAMENTO CO.
SUTTER CO.
ELDORADO CO.
McCLELLAN A.F.B.
AMERICAN RIVER
LAKE NATOMA
HIGHWAY 50
DRY CREEK
MINERS RAVINE
STRAP RAVINE
SECRET RAVINE
ANTELOPE CREEK
CLOVER VALLEY CREEK
LINDA CREEK
ROBLA CREEK
BASE LINE RD
DOUGLAS BLVD
SIERRA COLLEGE BLVD
ELVERTA RD
ELKHORN BLVD
ANTELOPE ROAD
OLD AUBURN ROAD
OAK AVE
GREENBACK LN
MADISON AVE
AUBURN BLVD
N
PLACER COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT
DRY CREEK WATERSHED FLOOD CONTROL PLAN
ALERT PRECIPITATION AND STREAM GAGE STATIONS
Scale
0 1/2 1
(Miles)
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Sacramento, California

FIGURE 4-2

TABLE 4-3
ALERT PRECIPITATION AND WATER LEVEL GAGES

Number	Name	Ownership
	ALERT Precipitation Gages	
220	Folsom Reservoir	National Weather Service
275	Navion	Sacramento County
276	Orangevale	Sacramento County
278	Rio Linda	Sacramento County
279	Chicago	Sacramento County
286	Van Maren	Sacramento County
291	Sunrise Blvd.	Sacramento County
295	American River College	Sacramento County
1601	Diamond Oaks Golf Course	Roseville
1602	Roseville Fire Station #2	Roseville
1604	Target	Roseville
1608	Miners Ravine at Sierra College Blvd.	Roseville
1612	Del Oro High School, Loomis	Roseville
1613	Strap Ravine at McLaren	Roseville
1614	Pine View School, Newcastle	Roseville
1616	Caperton Reservoir	Roseville
1617	Endora Lift Station	Roseville
1618	Sierra College	Roseville
1622	Antelope Creek	Roseville
1624	Loomis Observatory	Roseville
1628	Linda Creek at Champion Oaks	Roseville
1632	Dry Creek at Royer Park	Roseville
1645	Lincoln Airport	National Weather Service
1659	Elkhorn Blvd.	Sacramento County
6024	WWTP Booth Road	Roseville
6032	Roseville Water Treatment Plant	Roseville
6303	Auburn Dam	National Weather Service
	ALERT Water Level Sensors	
1603	Dry Creek at Vernon Street	Roseville
1605	Linda Creek at Oak Ridge	Roseville
1606	Miners Ravine at Sierra College Blvd.	Roseville
1607	Cirby Creek at Loretto Drive	Roseville
1611	Strap Ravine at McLaren	Roseville
1619	Secret Ravine at Rocklin Rd	Roseville
1621	Antelope Creek	Roseville
1625	Cirby Creek at Tina Way	Roseville
1626	Linda Creek at Champion Oaks	Roseville
1630	Dry Creek at Royer Park	Roseville

CHAPTER 5
RECOMMENDED PLAN

This chapter presents a summary of the recommended improvements and policies for the Dry Creek Watershed Flood Control Plan. Cost estimates for implementation of the recommended improvements and policies are included at the end of the chapter.

All aspects of the plan, both structural and nonstructural, have been designed to work together to provide increased flood control throughout the Dry Creek watershed. For example, the regional detention basins help to reduce watershed-wide flood flows, but due to siting restrictions cannot reduce flood flows in all tributaries.

STRUCTURAL IMPROVEMENT RECOMMENDATIONS

The following paragraphs describe the structural improvements that should be implemented as part of the Dry Creek Watershed Flood Control Plan. Figure 5-1a to 5-1e indicates the location of each of the proposed structural improvements. The various types of structural improvements have been designed to be implemented independently of each other because of uncertainties about the timing of construction of proposed improvements. For example, bridge and culvert replacements, and channel improvements have been designed to adequately pass the future 100-year flood flows assuming that no regional detention basins are constructed. It may be possible to reduce the size and cost of proposed bridges, culverts, and channel improvements if they are constructed after the regional detention basins.

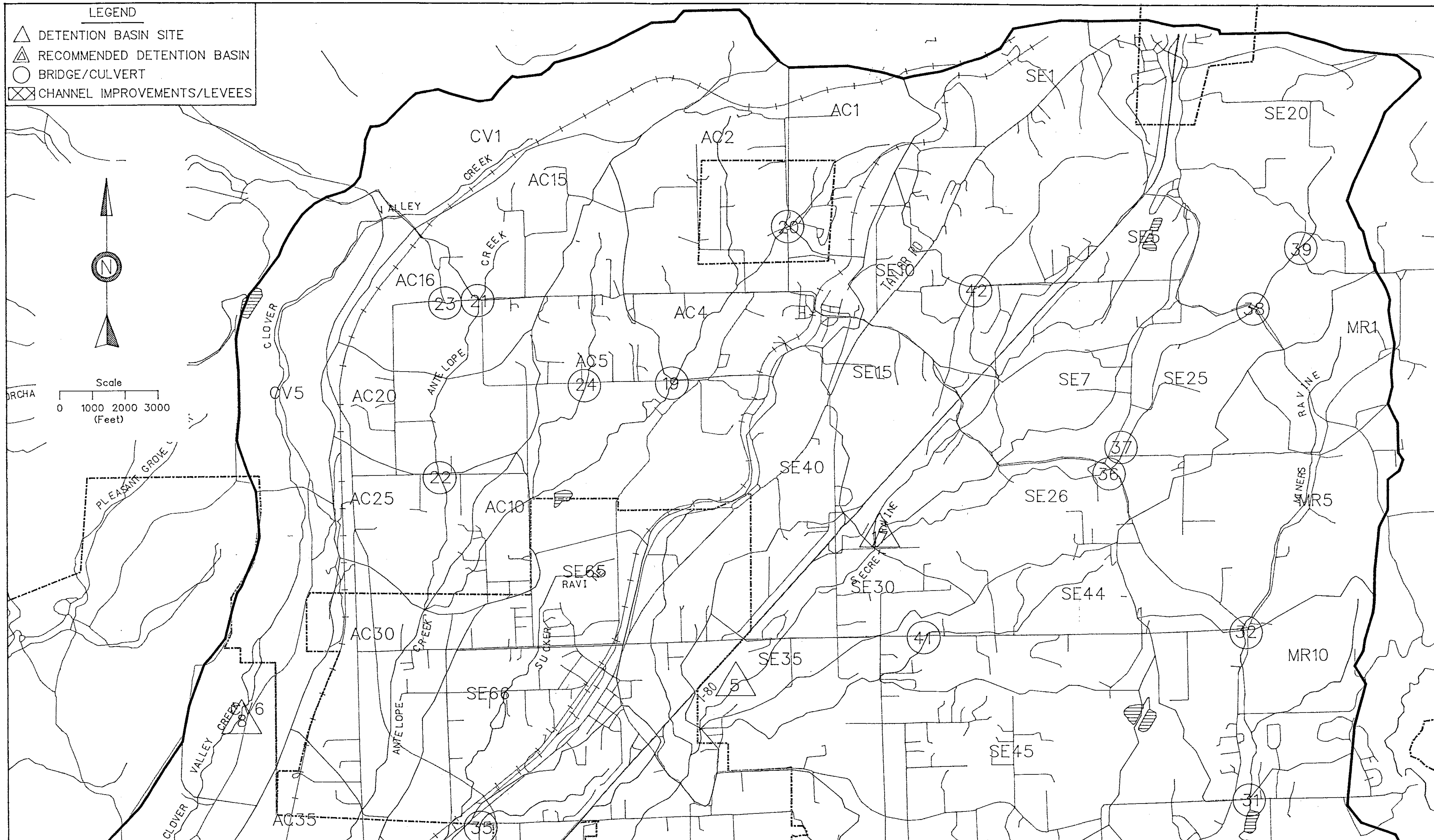
It is recommended that funds for the implementation of these improvements be collected from the properties in the watershed.

Regional Detention Basins

Seven regional detention basins are recommended for implementation as part of the Dry Creek Watershed Flood Control Plan. The locations for the regional detention basins are indicated on Figure 5-1a to 5-1e. A description of each basin, including the size and estimated cost, is given in Table 4-1.

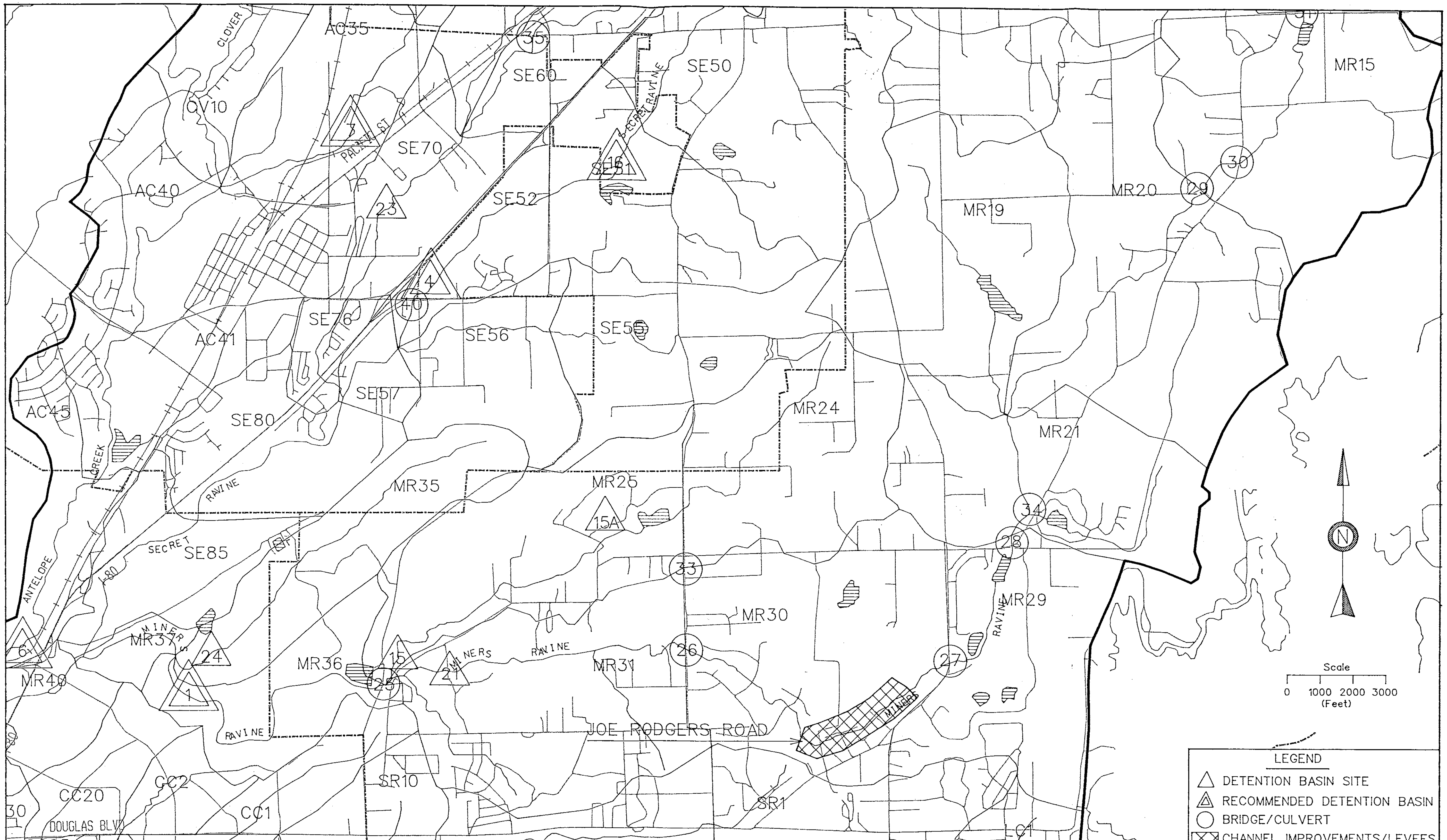
Detention Basin Feasibility Studies and Environmental Impact Reports. As part of this study, numerous sites (25) for regional detention facilities have been specified and examined. Of these 25 sites, seven were chosen for inclusion in the plan. These seven regional detention basins were evaluated hydrologically by including them in the HEC-1 model of the Dry Creek watershed. The height of the dams, storage volumes, and outlet descriptions were used to simulate the operation of the detention basins in the model. These simulations were sufficient for the reconnaissance level evaluation required for this study, however, before proceeding with the design and construction of the basins it will be necessary to conduct feasibility studies on each of the basins and then prepare an EIR addressing all of the environmental issues.

It is recommended that detailed studies of each of the detention basin sites and the stream reaches upstream and downstream of the basin be conducted. An evaluation of possible outlet designs should be made to determine the feasibility of controlling the flows to the desired levels. Site surveys should be conducted to determine the exact quantities and types of materials needed to build the dams, and to determine the precise storage volumes that would be available in the basins.



JMM James M. Montgomery Consulting Engineers, Inc. Sacramento, California	PLACER COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT	DRY CREEK WATERSHED FLOOD CONTROL IMPROVEMENTS MAP A

FIGURE 5-1A



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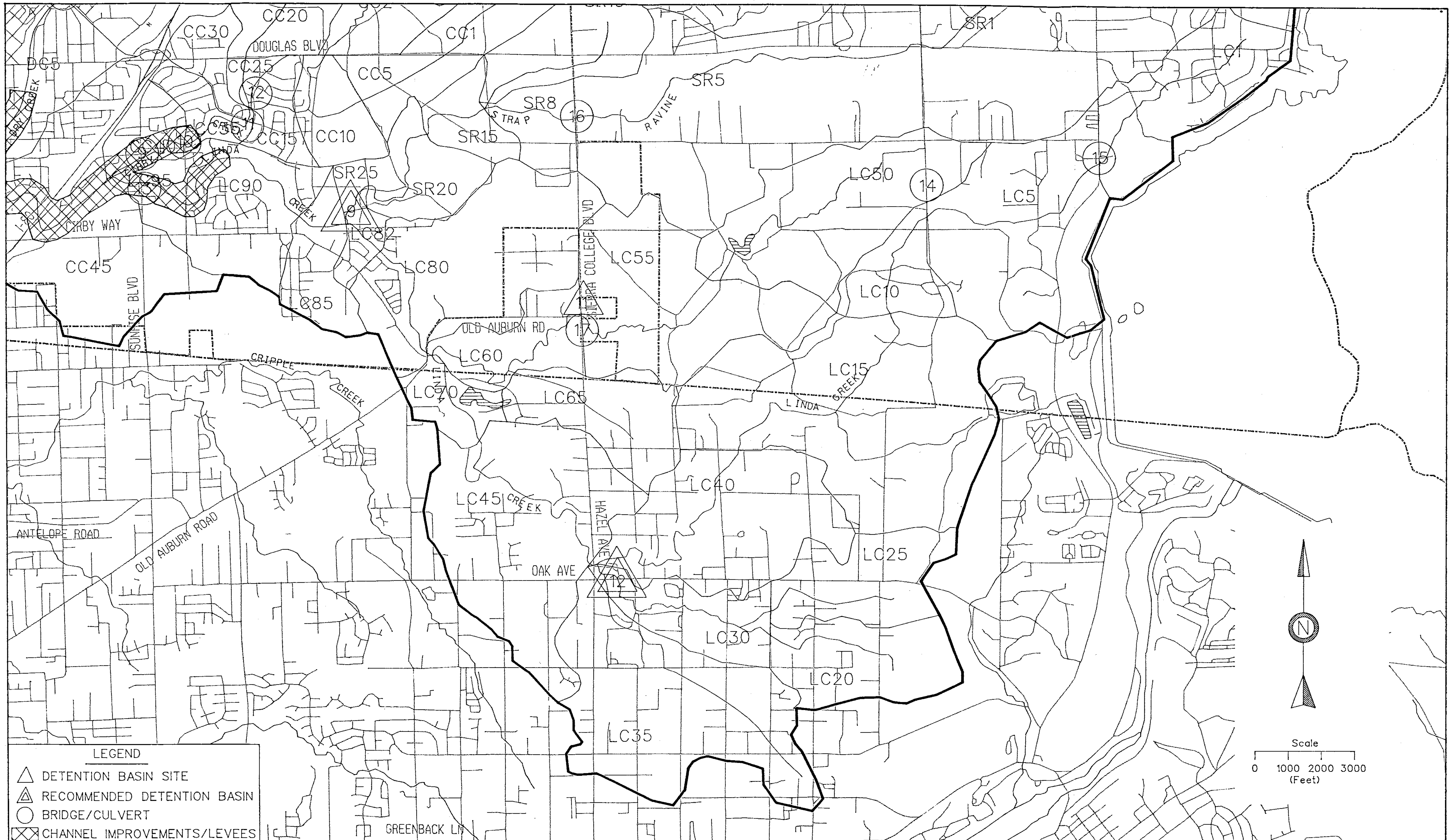
PLACER COUNTY FLOOD CONTROL
AND
WATER CONSERVATION DISTRICT

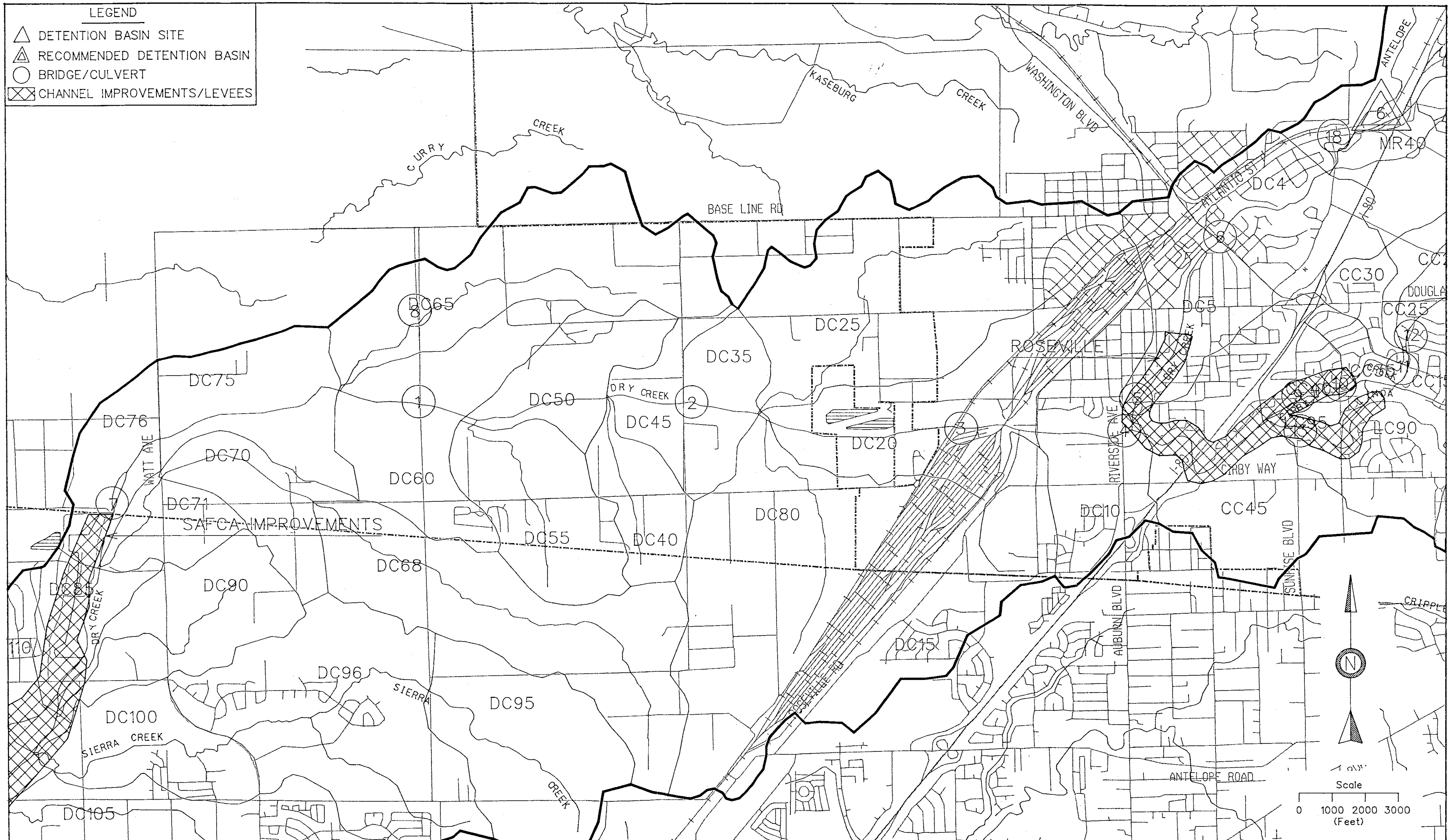
DRY CREEK WATERSHED
FLOOD CONTROL IMPROVEMENTS
MAP B

FIGURE 5-1B



JMM James M. Montgomery Consulting Engineers, Inc. Sacramento, California	PLACER COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT	DRY CREEK WATERSHED FLOOD CONTROL IMPROVEMENTS MAP C

FIGURE 5-1C



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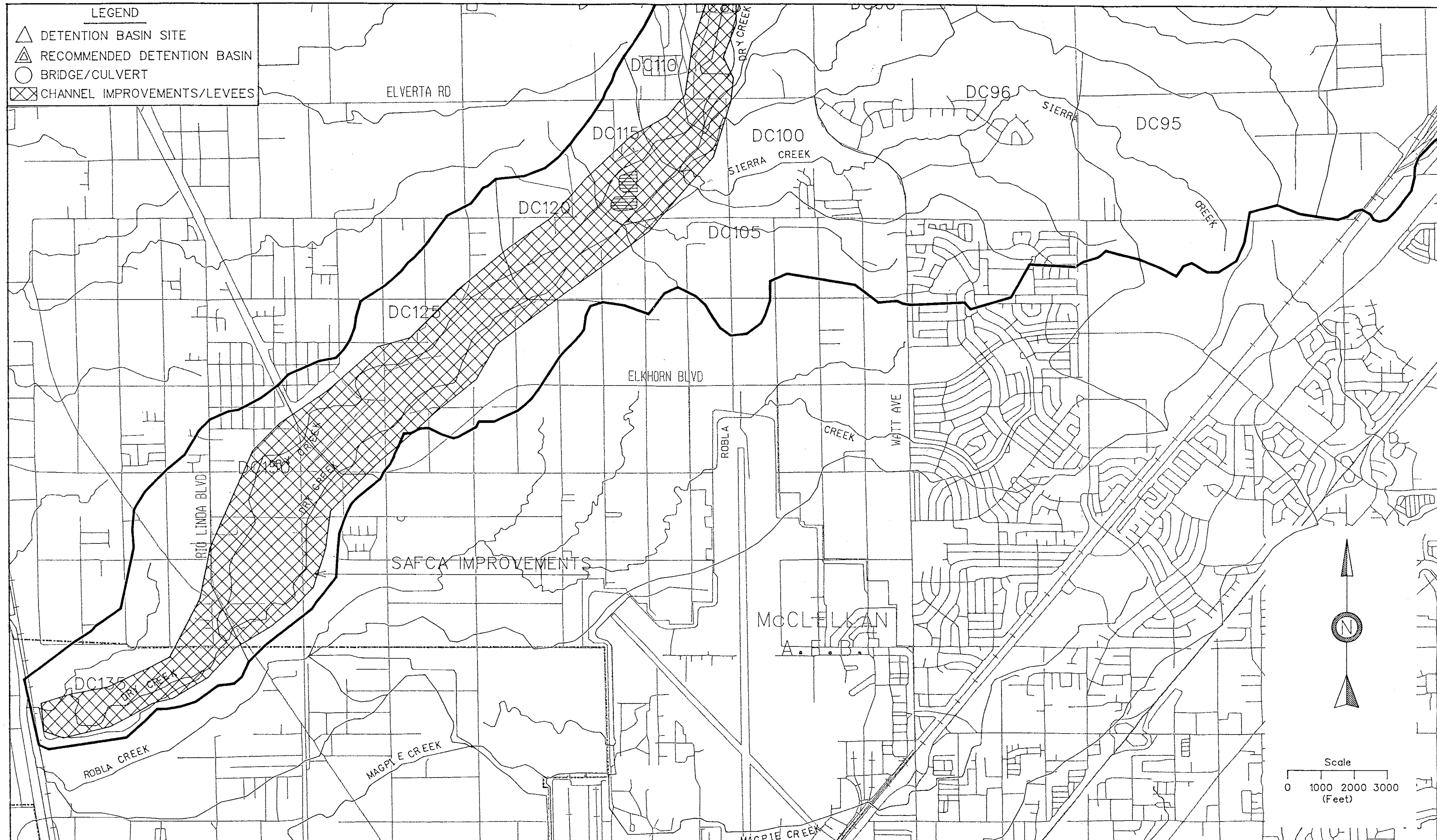
PLACER COUNTY FLOOD CONTROL
AND
WATER CONSERVATION DISTRICT

DRY CREEK WATERSHED
FLOOD CONTROL IMPROVEMENTS
MAP D

FIGURE 5-1D



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Sacramento, California

PLACER COUNTY FLOOD CONTROL
AND
WATER CONSERVATION DISTRICT

DRY CREEK WATERSHED
FLOOD CONTROL IMPROVEMENTS
MAP E

FIGURE 5-1E

Bridge And Culvert Replacement.

As described in Chapter 3, 70 percent of the bridges and culverts in the Dry Creek watershed are inadequate to pass the 100-year flood without overtopping. A project to replace all of the bridges and culverts in the watershed was judged to be economically infeasible. Bridges and culverts to be included in the Dry Creek Watershed Flood Control Plan were selected from the list of inadequate bridges and culverts by each of the jurisdictions in the watershed. Table 4-2 contains a description of each of the bridges and culverts selected for replacement. The locations of the recommended bridge and culvert replacements are shown as circles with numbers on Figure 5-1a to 5-1e.

Channel Improvements, Levees, And Floodwalls

Local channel improvement, levee, and/or floodwall projects are recommended for three locations in the Dry Creek watershed. Projects for two of the locations are currently under study (December 1991) by other jurisdictions. These two projects are the City of Roseville Channel Improvement Project on Cirby, Linda, and Dry Creeks in Roseville, and the SAFCA, Rio Linda Channel Improvement and Levee Project on Dry Creek in Rio Linda.

The other location, recommended for a channel improvement and floodwall project to be implemented by Placer County, is along Miners Ravine in the area of Joe Rodgers Road. The three projects are shown as shaded areas on Figure 5-1a to 5-1e and are discussed in Chapter 4.

NONSTRUCTURAL POLICY RECOMMENDATIONS

The following paragraphs describe the nonstructural policies that should be implemented as part of the Dry Creek Watershed Flood Control Plan.

Local, On-site Detention Basins

All new developments located in the shaded areas of the Dry Creek Watershed on Figure 5-2, should be required to provide local, on-site detention of stormwater flows except where it is determined by the District Engineer that local detention is either not required or not practical. There are some locations in the watershed where HEC-1 model studies have indicated that travel time and other timing consideration cause local detention to increase downstream flood flows over existing conditions. These subbasins are left unshaded on the map, along with other subbasins where local detention caused no net decrease in regional flood flows. It is therefore not cost effective to require local detention in those subbasins except for cases where local detention can solve a local flooding problem. These subbasins occur in the lower reaches of the watershed, downstream of the Roseville City limits.

Local, on-site detention should be designed to control the peak flow leaving the property as a result of the 10-, 25, and 100-year storms, such that there is no net increase in stormwater peak flows due to development. The design to accomplish this detention should be approved by the District Engineer.

Model studies in which local detention was simulated for all currently undeveloped areas of the Dry Creek watershed, indicated that even if local detention is successfully implemented for all of the future development in the watershed, the increased flows between pre- and post-development will only be reduced by 55 percent for the watershed as a whole. The difference in reduction between the 100 percent just downstream of each local detention basin, and the

55 percent for the watershed as a whole, is a result of travel time and other timing considerations that come into play when the entire Dry Creek watershed is considered.

Only in those situations where the District Engineer determines that topography or other factors will limit the effectiveness of local detention for a particular development, the developer shall make an in-lieu payment to the District. The payment will be based on the size and land use of the development. The developer will also be required to provide adequate land for an off-site detention basin. This in-lieu payment will be used by the District to defray the costs of increasing regional detention storage to handle the undetained flows from that development.

Floodplain Management

Floodplain Mapping. Floodplain mapping is essential to provide direction for the various jurisdictions as land is developed along the streams in the Dry Creek watershed. FEMA has prepared floodplain maps for a number of stream reaches in the watershed. However, the maps were prepared using flood flows based on outdated watershed hydrology and in many cases do not accurately represent the extent of the existing floodplain. Also, FEMA will only prepare floodplain delineations based on current land use in a watershed, whereas the jurisdictions in the watershed would like to have the floodplain mapping information available for Future conditions.

It is recommended that a systematic approach to the ongoing mapping of floodplains in the Dry Creek watershed be implemented and funded by the Flood Control District. This approach would insure that the mapping is current and is based on the future flood flows that will occur in the watershed.

The first step in this approach will be to map the floodplains for all major streams, as defined above and shown in Figure 2-9. This mapping may be either done in conjunction with or in addition to the mapping that FEMA will be conducting in the coming year. The floodplain mapping and analysis done by FEMA can be used as a starting point and the floodplains for future flows can be added.

Once all of the floodplains of major streams in the watershed have been mapped for Future condition flood flows, it will be necessary to update the mapping on a scheduled basis to account for development in the watershed and/or changes in land use or other factors. It is suggested that floodplain mapping be checked every two years, and where changes affecting flood flows are found to be significant the floodplain mapping should be checked and redone if needed.

Channel and Floodplain Clearing. The stream channels and floodplains in many areas of the Dry Creek Watershed are densely vegetated with trees, bushes, blackberries, vines, and bamboo. The model studies conducted for this plan have demonstrated that removal of this vegetation, which acts as a natural flow retarding system, will increase the flood flows in the channels.

It is recommended that floodplain management and grading ordinances and policies be enacted where such ordinances and policies are not already in place. These ordinances should restrict the removal of riparian vegetation from the channels and floodplains of major streams in the Dry Creek watershed. Clearing would be allowed in those exceptional cases where other considerations, such as health and safety, or potential damage to structures, require removal of the vegetation. Reduction of vegetative cover would also be allowed where increases in vegetation in the future change the channel and floodplain flow characteristics sufficiently to place existing structures in danger from flooding. Clearing would only be

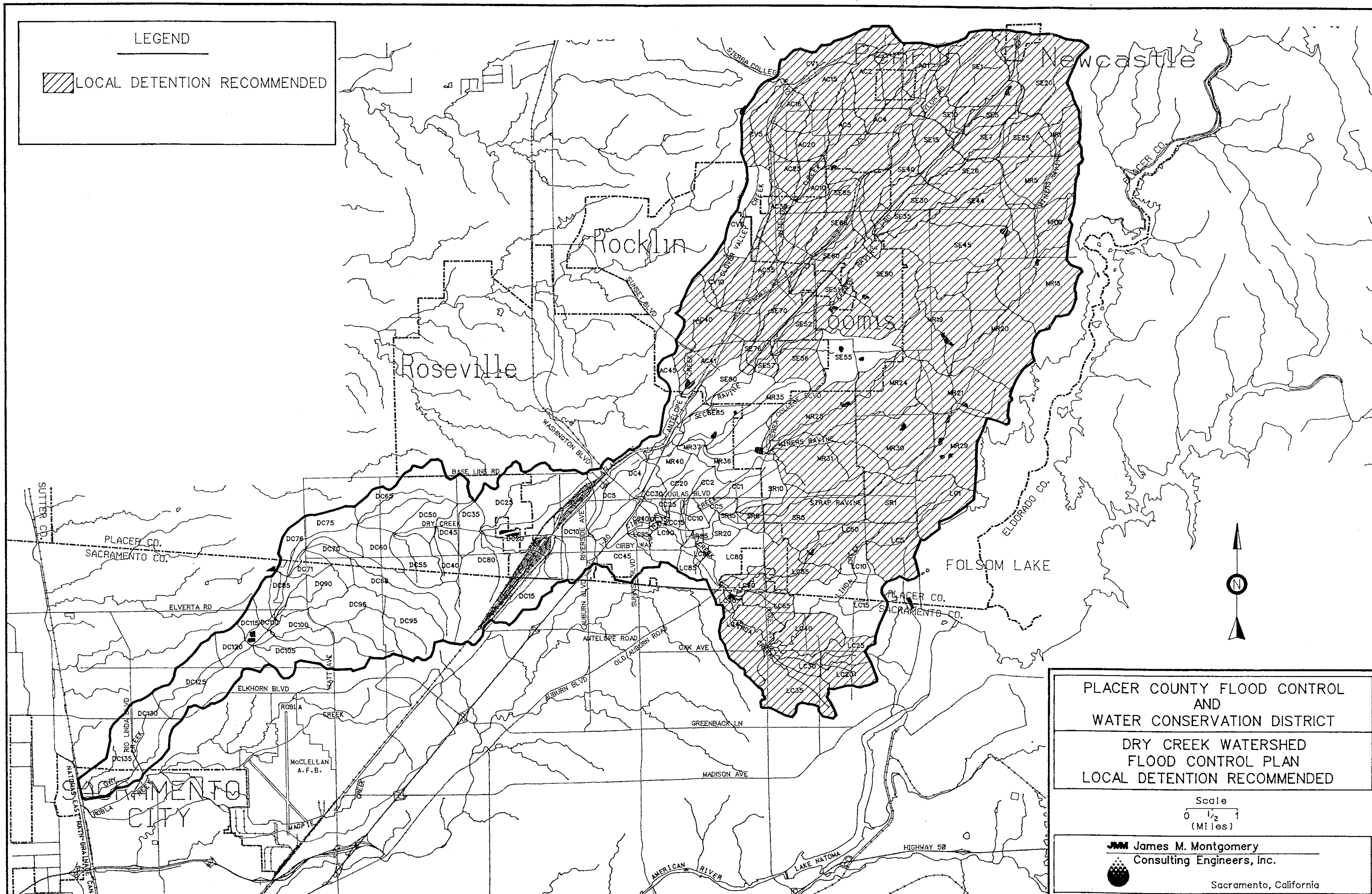

LEGEND
LOCAL DETENTION RECOMMENDED
PLACER COUNTY FLOOD CONTROL
AND
WATER CONSERVATION DISTRICT
DRY CREEK WATERSHED
FLOOD CONTROL PLAN
LOCAL DETENTION RECOMMENDED
Scale
0 1/2 1
(Miles)
James M. Montgomery
Consulting Engineers, Inc.
Sacramento, California
Newcastle
Penryn
Rocklin
Loomis
Roseville
SACRAMENTO
CITY
FOLSOM LAKE
PLACER CO.
SACRAMENTO CO.
SUTTER CO.
ELDORADO CO.
McCLELLAN
A.F.B.
BASE LINE RD
ELVERTA RD
ELKHORN BLVD
ANTELOPE ROAD
OLD AUBURN ROAD
AUBURN BLVD
OAK AVE
GREENBACK LN
MADISON AVE
HIGHWAY 50
AMERICAN RIVER
LAKE NATOMA
WASHINGTON BLVD
SUNSET BLVD
SIERRA COLLEGE
DRY CREEK
STRAP RAVINE
MINERS RAVINE
N

FIGURE 5-2

allowed to return floodplain and channel to the approximate conditions existing at the time of the adoption of this plan.

Major streams, for the purpose of these ordinances, are defined as those streams carrying more than 200 cfs in the 10-year flood. The locations of all streams in the watershed that meet these criteria are indicated on the map in Figure 2-9.

Flood Warning System

It is recommended that the Flood Control District acquire an ALERT base station and software as well as additional ALERT stations. A review of flood problems during the February 18-19, 1986 flood indicated that some additional locations of water level sensors would be desirable. These locations should also include a precipitation gage that can be installed at a small increase in cost and will provide better backup and storm definition. These locations are, in order of desirability:

- Miners Ravine at Dick Cook Road in Placer County
- Antelope Creek at Sierra College Blvd. in Loomis
- Linda Creek at Hazel Avenue in Orangevale
- Dry Creek at Watt Avenue in Placer County

None of the existing ALERT water level sensors have adequate rating curves to convert water level to stream flow. Some theoretical and low flow relationships are available from the City of Roseville for Dry Creek gages 1603 and 1630, Linda Creek gages 1605 and 1626, and Cirby Creek gages 1625 and 1607.

The District should initiate a program to monitor and develop stage rating curves at all of the water level gages in the combined ALERT system in Placer County. The goal of this monitoring program is twofold. First, after sufficient data is collected, rating curves can be developed to increase the accuracy of the flow data collected by the gages. Second, flow information collected by the gages in the network can be used to assess the effectiveness of the various mitigation measures proposed by this plan as they are enacted. This ongoing monitoring of flows in the watershed will allow the District to modify alternatives and implementation measures if required to obtain the maximum benefits.

RESULTS OF PLAN IMPLEMENTATION

Some of the results of the implementation of the Flood Control Plan are illustrated in Table 5-1. The table contains peak flow information for the 100-year flood for existing and future conditions, with and without the recommended regional and local detention basins. Other aspects of the recommended Flood Control Plan will provide significant results, but these results are not as easy to represent and quantify. Bridge and culvert replacements will result in better access throughout the watershed and significantly lower flood damages to highway structures during a 100-year flood event. The recommended channel improvements, levees, and floodwalls will help to protect those structures that have already been built inside the 100-year floodplain.

Floodplain mapping throughout the watershed will help to prevent further construction inside the 100-year floodplains, thus preventing flood damages to structures. The recommended channel and floodplain clearing ordinances will leave intact the natural flood detention facilities provided by the dense vegetation along streams in the Dry Creek Watershed.

TABLE 5-1
RESULTS OF PLAN IMPLEMENTATION

Distance From Mouth (ft)	Location Description	No Plan 100-Year 1989 (cfs)	No Plan 100-Year Future (cfs)	Plan 100-Year Future (cfs)
DRY CREEK				
8900	Rio Linda Blvd (North & South)	14182	15642	11489
15000	Elkhorn Blvd (North & South)	14183	15637	11477
16600	Curved Bridge Road (North)	14173	15626	11464
17400	Dry Creek Road (North & South)	14171	15623	11461
24400	Q Street (North & South)	14228	15668	11479
34900	Sierra Creek Confluence	14184	15612	11413
35200	28th Street (South)	14051	15435	11238
35400	Elverta Road	14028	15406	11209
36900	Confluence County Line Trib.	14048	15414	11215
41400	Watt Avenue	14007	15331	11124
47700	Confluence with DC65 Trib	14029	15348	11130
50300	Walerga Road	13973	15278	11057
58800	Cook Riolo Road	13950	15208	10988
67000	S. P. Railroad Spur	13767	14932	10711
67400	Atkinson Blvd	13767	14932	10711
68900	S.P. Railroad Culverts	13764	14916	10695
69900	Vernon Street	13706	14830	10609
72600	Riverside Avenue	13825	15181	10636
73000	Cirby Creek Confluence	13825	15181	10636
73800	Darling Way	10370	11272	7217
77000	Douglas Blvd.	10365	11262	7207
77500	Royer Park Footbridge	10476	11358	7200
79100	Lincoln Street	10474	11354	7196
79400	Folsom Road	10479	11349	7195
84100	Antelope Cr/Miners Ravine	10462	11312	7153
DRY CREEK/ELVERTA TRIB.				
	Confluence with Dry Creek	344	467	467
DRY CREEK/SIERRA CREEK				
0	Confluence with Dry Creek	1575	1984	1753
1400	28th Street	1539	1942	1678
3700	Scotland Drive	1456	1843	1590
5400	Delaney Drive	1419	1816	1502
6800	Watt Avenue	1380	1774	1427
10300	Navaho Way	831	1041	937
11400	Elverta Road	714	884	832
13500	Walerga Road	596	727	727
DRY CREEK/COUNTY LINE TRIB.				
0	Confluence with Dry Creek	671	982	640
3200	Watt Avenue	630	960	617
8200	PFE Road	471	762	762
DRY CREEK/DC65 TRIB.				
0	Confluence with Dry Cr	484	524	524
3000	Walerga Road	387	419	419
CIRBY CREEK				
0	Dry Creek Confluence	4126	4613	3443
3000	Interstate 80	4106	4592	3423
4600	Wanda Lee Court Footbridge	4118	4614	3424
6100	Linda Creek Confluence	4113	4614	3411
7400	Sunrise Blvd.	793	1098	717
8100	Coloma Way	842	1113	736

TABLE 5-1 (Continued)

Distance From Mouth (ft)	Location Description	No Plan 100-Year 1989 (cfs)	No Plan 100-Year Future (cfs)	Plan 100-Year Future (cfs)
9100	Oak Ridge Drive	866	1138	737
10000	Sierra Gardens Footbridge	860	1132	732
11800	Loretto Drive	851	1135	708
12000	Sierra Gardens Trib. Conf.	867	1135	680
12500	Sierra Gardens Drive	696	969	661
13900	Huntington Drive	659	984	556
14500	Rocky Ridge Drive	409	565	346
16400	Winchester Way	356	505	305
17200	Eureka Road	357	557	304
19700	Douglas Blvd.	215	435	394
CIRBY	CREEK/SIERRA GARDENS TRIB.			
0	Cirby Creek Confluence	141	172	680
1000	Douglas Blvd	147	150	145
1400	Sierra Gardens Ret. Basin	140	143	138
LINDA	CREEK			
0	Cirby Creek Confluence	3972	4464	3115
1000	Sunrise Avenue	3970	4461	3112
2600	Oak Ridge Drive	3991	4565	3247
4300	Sierra Gardens Footbridge	3985	4555	3241
8400	Rocky Ridge Drive	4159	4624	3292
10000	Strap Ravine Confluence	4097	4538	3283
11500	Champion Oaks Drive	3297	3612	2602
14300	Auburn Road	3343	3649	2574
15700	Old Auburn Road/City Limits	3285	3577	2569
15900	Treelake Trib. Confluence	3285	3577	2569
19800	Indian Creek Drive	2489	2774	1837
25300	Hazel Avenue	2220	2465	1608
25500	Orangevale Trib. Confluence	2220	2465	1608
31300	Granite Avenue	1251	1380	1150
32600	Cherry Avenue	1230	1351	1118
38600	Wedgewood Drive	887	1031	826
42300	East Roseville Parkway	809	995	778
43100	Barton Road	762	943	775
44600	Shadow Brook Place	642	797	650
46500	Purdy Lane	473	640	494
48100	Country Court	390	553	413
48700	Auburn Folsom Road	349	510	373
LINDA	CREEK/STRAP RAVINE			
0	Linda Creek Confluence	915	1050	754
1500	McClaren Drive	920	1054	918
5900	Johnson Ranch Drive	916	1053	911
6800	Eureka Road	915	1053	909
8600	East Roseville Parkway	905	1060	901
11800	Sierra College Blvd.	854	1112	819
23000	Barton Road	652	1020	839
LINDA	CREEK/TREELAKE TRIB.			
0	Linda Creek Confluence	847	958	732
3200	Petite Way	793	888	617
5700	Old Auburn Road	802	982	640
6000	Sierra College Blvd.	797	985	633
9600	Swan Lake Drive	579	699	522
9600	Swan Lake	579	699	522
10800	Waterbury Way	496	589	479
10800	Waterbury Lake	496	589	479

TABLE 5-1 (Continued)

Distance From Mouth (ft)	Location Description	No Plan 100-Year 1989 (cfs)	No Plan 100-Year Future (cfs)	Plan 100-Year Future (cfs)
11400	East Roseville Parkway	429	503	462
11400	E. Roseville Parkway Pond	429	503	462
11700	Treelake Office Lane	429	503	462
11700	Treelake Office Lane Pond	429	503	462
LINDA CR/HAZEL AVE. TRIB. (Sac. Cty)				
0	Linda Creek Confluence	708	879	649
400	Oak Avenue	708	879	649
LINDA CR/ORANGEVALE TRIB. (Sac. Cty				
0	Linda Creek Confluence	1298	1393	927
900	Oak Avenue	664	711	626
3300	Filbert Avenue	624	668	564
4300	Chestnut Avenue	689	750	570
5500	Walnut Avenue (North)	297	298	223
5500	Walnut Avenue (South)	326	409	251
6700	Main Avenue (North)	223	224	167
6700	Main Avenue (South)	228	286	176
ANTELOPE CREEK				
0	Miners Ravine/Dry Cr.	3075	3486	1804
1400	Harding Blvd.	3074	3485	1796
2300	Atlantic Street	3072	3483	1787
5000	County Dump Road	3065	3477	1745
9600	Highway 65	3086	3500	1673
10300	Springview Drive	3176	3612	1644
10800	Rocklin City Trib. Conf.	3161	3592	1594
15800	Sunset Blvd.	3104	3519	1539
22800	Clover Valley Cr. Confluence	3165	3593	1445
23600	Midas Avenue	2330	2703	697
25700	Southern Pacific Railroad	2310	2683	686
26500	Yankee Hill Road	2303	2676	683
27600	Atchinson Dairy Dam	2283	2655	672
28900	Unnamed Road	2262	2634	662
31800	Delmar Avenue	2242	2607	1982
34300	Sierra College Blvd.	2180	2541	1900
37000	King Road	2137	2485	1827
ANTELOPE CR/CLARK TUNNEL RD TRIB.				
0	Antelope Creek Confluence	2132	2496	1800
100	Barker Road	1268	1603	1033
1300	Humphrey Road	1155	1537	994
1700	Humphrey Trib. Confluence	1136	1510	984
7000	Colwell Road	811	1174	671
10000	English Colony Way	759	1152	585
12800	Clark Tunnel Road	297	515	384
ANTELOPE CR/ROCKLIN CITY TRIB.				
0	Antelope Creek Confluence	190	243	202
2700	Taylor Road	142	182	152
3800	Taylor Road	119	152	127
4500	Sunset Blvd.	71	91	76
ANTELOPE CR./CLOVER VALLEY CR.				
0	Antelope Cr. Confluence	857	934	384
400	Argonaut Avenue	855	931	401
2200	Footbridge and Weir	842	915	486
4300	Midas Avenue	837	908	520

TABLE 5-1 (Continued)

Distance From Mouth (ft)	Location Description	No Plan 100-Year 1989 (cfs)	No Plan 100-Year Future (cfs)	Plan 100-Year Future (cfs)
4700	Abandoned Stone Bridge	837	908	558
5600	Unnamed Bridge	829	898	628
6500	Clover Valley Det. Pond	825	892	662
7700	Creekwood Drive	817	882	732
12000	Rawhide Road	744	819	676
12500	Rawhide Road Det. Pond	734	810	668
25600	Unnamed Road	478	576	460
28000	Sierra College Blvd	422	519	414
28500	English Colony Way	422	519	414
ANTELOPE CREEK CONTINUED				
38700	Clark Tunnel Rd. Trib. Confluence	864	893	767
40600	Barker Road	770	819	669
42500	Citrus Colony Road	732	800	630
47900	English Colony Way	380	484	357
ANTELOPE CR./HUMPHREY TRIB.				
0	Clark Tunnel Rd. Trib. Confluence	364	462	392
1700	Sandy Road	255	323	274
3300	Mardell Lane	218	277	235
3700	Colwell Road	182	231	196
6300	English Colony Way	109	138	118
MINERS RAVINE				
0	Antelope Cr./Dry Cr.	7844	8428	5590
200	Harding Blvd.	7843	8424	5586
1500	Interstate 80	7837	8412	5570
2800	Eureka Way	7842	8409	5580
3800	Secret Ravine Confluence	7815	8344	5578
5300	Sunrise Avenue	6149	6642	4229
7000	Boardman Tributary	1594	1814	883
9000	East Roseville Parkway	3885	4468	3778
18200	Sierra College Blvd.	3847	4465	3758
18300	Cavitt Stallman Trib.	3847	4465	3758
18600	Cavitt & Stallman Road	3241	3823	2940
23400	Shadow Oaks Lane	3171	3745	2861
28900	Barton Road	3101	3671	2813
31300	Tall Pine Lane	3041	3603	2717
33000	Carolinda Drive	2982	3535	2621
34800	Itchy Acres Road	2936	3484	2530
35500	Miners Ravine Road	2909	3453	2483
36800	Leibinger Lane	2881	3421	2436
39700	Auburn Folsom Road	2766	3278	2342
41700	Oak Lake	2706	3206	2295
43000	Old Bridge	2689	3210	2271
43200	Cottonwood Lake	2680	3202	2262
44400	Auburn Folsom Road	2694	3204	2253
45600	Confluence w/ lake trib. (MR19)	2568	3061	2166
56000	Moss Lane	2468	2967	2097
59900	Dick Cook Road	1787	2277	1428
61500	Auburn Folsom Road	1691	2154	1343
62400	Placer Canyon Parkway	1596	2031	1258
67600	Horseshoe Bar Road	1299	1645	1000
71700	Auburn Folsom Road	1008	1304	756
73300	King Road	949	1234	695
79400	Penryn Rock Springs Rd.	277	376	238
80200	Newcastle Road	166	226	143

TABLE 5-1 (Continued)

Distance From Mouth (ft)	Location Description	No Plan 100-Year 1989 (cfs)	No Plan 100-Year Future (cfs)	Plan 100-Year Future (cfs)
MINERS RAVINE/BOARDMAN TRIB.				
0	Miners Ravine Confluence	414	530	530
800	East Roseville Parkway	393	504	504
MINERS RAV./CAVITT & STALLMAN TR				
0	Miners Ravine Confluence	595	688	1029
2400	Hidden Valley Place	566	655	961
3100	Baywood Road	537	621	894
3700	S Bar B Lane	508	588	826
4500	Kokula Lane	479	554	758
5100	Crestview Lane	451	521	691
9300	Barton Road	496	665	782
MINERS RAVINE/LAKE TRIB. (MR21)				
0	Miners Ravine Conf.	314	404	404
200	Auburn Folsom Road	353	454	454
300	South Lake Circle	353	454	454
SECRET RAVINE				
0	Miners Ravine Confluence	4197	4332	3434
1400	East Roseville Parkway	4196	4331	3431
13500	Sucker Ravine Confluence	4151	4320	3498
16200	Aguilar Rd. Trib. Conf.	3706	4045	2745
17600	Rocklin Road	3374	3820	2808
23300	Sierra College Blvd.	3375	3814	2763
28800	Private Road	3183	3714	2902
29200	Private Road	3171	3705	2880
30800	Brace Road	3090	3649	2719
32600	Horseshoe Bar Road	3088	3684	2594
33400	Loomis Trib. Confluence	3078	3676	2588
33500	King Rd. Trib. Conf.	2853	3481	2480
38600	King Road	2358	2877	1954
40000	Penryn Road	2337	2856	1915
40500	Harris/Boulder Cr. Road	2331	2850	1904
40700	Penryn Trib. Confluence	2346	2852	1898
43300	Boulder Creek Road	1961	2371	1564
48500	Brennans Road	1146	1369	827
48900	Rock Springs Road	1118	1340	804
50400	Meadow Lane	1032	1254	734
51300	Los Puentes Road	1058	1394	840
55300	Newcastle Road	927	1297	849
57700	Powerhouse Road	649	908	594
SECRET RAVINE/SUCKER RAVINE				
0	Secret Ravine Conf.	1144	1330	1022
1000	China Garden Road	1140	1326	1017
1200	Interstate 80	1138	1324	1015
2200	Oakridge Street	1138	1324	1015
2600	Lakeside Drive	1157	1358	1071
3950	Rocklin Road	1169	1385	1116
4300	Quarry Lake	1160	1377	1106
4700	Super Span	1151	1369	1096
7450	Sierra Meadows Drive	1125	1344	1065
10800	Dominguez Road	1065	1363	990
11000	Loomis Trib. Conf.	1085	1366	983
13400	Pacific Street	607	514	197
14800	Bankhead Road	556	476	209

TABLE 5-1 (Continued)

Distance From Mouth (ft)	Location Description	No Plan 100-Year 1989 (cfs)	No Plan 100-Year Future (cfs)	Plan 100-Year Future (cfs)
15200	Sierra College Blvd.	540	463	213
19000	Saunders Avenue	531	651	538
20200	King Road	541	669	553
SECRET RAV./SUCKER RAV./LOOMIS TI				
0	Sucker Ravine Confluence	380	730	730
4400	Sierra College Blvd.	209	402	402
SECRET RAVINE/AGUILAR RD. TRIB.				
0	Secret Ravine Conf.	566	744	796
700	Aguilar Road	549	718	769
2400	Foothill Road	516	666	714
4100	El Don Road	491	627	673
4100	El Don Detention Pond	491	630	679
6100	Sierra College Blvd.	462	583	583
SECRET RAVINE/LOOMIS TRIB.				
0	Secret Ravine Conf.	473	710	650
1200	Interstate 80	437	656	600
2800	Laird Street	411	618	565
3600	King Road	386	579	530
SECRET RAVINE/KING ROAD TRIB.				
0	Secret Ravine Conf.	1367	1500	1267
3900	Rancho Verde Road	1270	1395	1173
5400	Val Verde Road	419	505	430
6300	King Road	377	455	387
SECRET RAVINE/PENRYN TRIB.				
0	Secret Ravine Conf.	999	1410	849
4700	Rock Springs Road	1024	1528	888
5600	East/West Forks Conf.	881	1421	773
SECRET RAV./E. FORK PENRYN TRIB.				
0	West Fork Confluence	255	356	271
900	Fairview Lane	228	319	242
3700	Gilardi Road	94	131	100
SECRET RAV./W. FORK PENRYN TRIB.				
0	East Fork Confluence	595	999	165
200	Interstate 80	593	994	182
1400	Gilardi Road	567	1024	456

COST ESTIMATES

One of the most important objectives for the Dry Creek Watershed Flood Control Plan is to develop cost estimates for required flood control projects in the watershed. The purpose of this section is to present the cost estimates for the various flood control alternatives. Cost estimates are provided for both the structural and non-structural alternatives. Table 5-2 contains the cost estimates for the structural flood control alternatives while Table 5-3 contains the cost estimates for the non-structural alternatives.

The following describes the criteria that were used in coming up with the cost estimates found in the table. Specifically, the cost factors for contingencies and engineering and administration will be discussed, followed by the structural alternatives cost criteria and then the non-structural alternatives' criteria.

Construction Contingencies

The construction contingency's cost is added to the cost estimate to cover unforeseen problems that may occur during the construction of the alternatives defined in this Flood Control Plan. These costs may also include contractor mobilization and planning. For this Flood Control Plan, these costs have been estimated as 20 percent of the construction cost. Contingencies were added to all of the structural alternatives, but were not included in any of the non-structural alternatives except for the installation of the flood warning system.

Engineering and Administration

Engineering and administration is estimated to be 25 percent of the total construction cost. The engineering portion is 15 percent and is intended to cover all costs associated with the design engineering of the project. These costs include project level engineering studies, reports, preparation of final plans, specifications, contract documents, and engineering services during project construction. To cover those activities associated with the construction of the project that are not directly related to engineering, an administration/legal contingency of 10 percent has been included.

Environmental Analysis

Environmental analysis is estimated to be 10 percent of the total construction cost. This analysis includes wetland delineation and mitigation plans, environmental impact statements, and discussions with agencies such as Fish and Game and the EPA.

Structural Alternatives Cost Criteria

The following paragraphs present a brief discussion of the assumptions used in developing the unit costs for corrugated metal pipes, reinforced concrete box culverts, bridge construction, unlined channels, floodwalls, detention basin facilities, and land acquisition.

Corrugated Metal Pipes. Corrugated metal pipes (CMP) and pipe arches (CMPA) are used where existing pipe culverts need to be replaced. To estimate the cost of the pipes, a relationship was developed between pipeline diameter and the cost of the pipe in dollars per linear foot of pipe, based on data from the Means and Richardson cost manuals. Pipe costs included the cost of imported bedding material for the pipes. The labor costs per linear foot of pipe installation were estimated using a typical cross section to determine the amount of material to be removed, and then estimating the time for a typical construction crew to install each foot of pipe. Pavement reconstruction assumed a 35 foot by 35 foot section of roadway to be repaired at each site with a unit cost of $2.50 per square foot.

TABLE 5-2

COST ESTIMATES, STRUCTURAL ALTERNATIVES

Item No.	Stream Cross. No.	Description	Construction Cost	Contingency at 20%	Engineering & Admin. at 25%	Environmental Analysis at 10%	Land Cost	Total Cost
		REGIONAL DETENTION BASINS						
1	185	Miners Ravine below Sierra College Blvd.	$914,136	$182,827	$228,534	$91,414	$0	$1,416,911
4	231	Secret Ravine U.S. of Rocklin Rd nr. Sierra Coll.	$725,172	$145,034	$181,293	$72,517	$0	$1,124,017
6	124	Antelope Creek at Atlantic Street	$342,190	$68,438	$85,548	$34,219	$0	$530,395
7	138	Antelope Creek D.S. of Delmar Avenue	$827,946	$165,589	$206,987	$82,795	$5,005,000	$6,288,316
9	96	Strap Ravine at McLaren Dr. in Maidu Park	$165,757	$33,151	$41,439	$16,576	$0	$256,923
12	117	Linda Cr. Orangevale Trib. in Orangevale Park	$108,763	$21,753	$27,191	$10,876	$0	$168,583
16	232	Secret Ravine U.S. of Sierra College Blvd.	$647,141	$129,428	$161,785	$64,714	$1,430,000	$2,433,069
		Regional Detention Basin Total						$12,218,213
		BRIDGE AND CULVERT REPLACEMENT						
1	14	Dry Creek @ Walerga Road	$135,022	$27,004	$33,756	N/A	N/A	$195,782
2	16	Dry Creek @ Cook Riolo Road	$154,310	$30,862	$38,578	N/A	N/A	$223,750
3	18	Dry Creek @ Atkinson Blvd	$61,827	$12,365	$15,457	N/A	N/A	$89,649
4	22	Dry Creek @ Riverside Avenue	$1,028,736	$205,747	$257,184	N/A	N/A	$1,491,667
5	24	Dry Creek @ Darling Way	$213,784	$42,757	$53,446	N/A	N/A	$309,987
6	28	Dry Creek @ Folsom Road	$267,471	$53,494	$66,868	N/A	N/A	$387,833
7	41	Dry Creek County Line Trib. @ Watt Ave.	$46,600	$9,320	$11,650	N/A	N/A	$67,570
8	44	Dry Creek DC65 Trib. @ Walerga Road	$35,450	$7,090	$8,863	N/A	N/A	$51,403
9	50	Cirby Creek @ Sunrise Boulevard	$67,930	$13,586	$16,983	N/A	N/A	$98,499
10	52	Cirby Creek @ Oak Ridge Drive	$22,861	$4,572	$5,715	N/A	N/A	$33,148
11	54	Cirby Creek @ Loretto Drive	$74,560	$14,912	$18,640	N/A	N/A	$108,112
12	56	Cirby Creek @ Sierra Gardens Drive	$22,861	$4,572	$5,715	N/A	N/A	$33,148
13	68	Linda Creek @ Sunrise Avenue	$297,369	$59,474	$74,342	N/A	N/A	$431,185
14	90	Linda Creek @ Barton Road	$103,555	$20,711	$25,889	N/A	N/A	$150,155
15	94	Linda Creek @ Auburn-Folsom Road	$18,122	$3,624	$4,531	N/A	N/A	$26,277
16	100	Strap Ravine @ Sierra College Blvd.	$70,308	$14,062	$17,577	N/A	N/A	$101,947
17	105	Linda Cr. Treelake Trib. @ Sierra Coll. Blvd.	$39,190	$7,838	$9,798	N/A	N/A	$56,826
18	123	Antelope Creek @ Harding Boulevard	under const.	$0	$0	N/A	N/A	$0
19	148	Antel. Cr/Clark Tunnel Rd Trib. @ Colwell Rd	$35,450	$7,090	$8,863	N/A	N/A	$51,403

TABLE 5-2 (Continued)

Item No.	Stream Cross. No.	Description	Construction Cost	Contingency at 20%	Engineering & Admin. at 25%	Environmental Analysis at 10%	Land Cost	Total Cost
20	150	Ant. Cr/Clark Tun. Rd Trib. @ Clark Tunnel R	$23,633	$4,727	$5,908	N/A	N/A	$34,268
21	167	Clover Valley Creek @ English Colony Rd.	$11,029	$2,206	$2,757	N/A	N/A	$15,992
22	171	Antelope Creek @ Citrus Colony Road	$192,888	$38,578	$48,222	N/A	N/A	$279,688
23	172	Antelope Creek @ English Colony Road	$96,444	$19,289	$24,111	N/A	N/A	$139,844
24	176	Antelope Cr. Humphrey Trib. @ Colwell Rd.	$31,067	$6,213	$7,767	N/A	N/A	$45,047
25	186	Miners Ravine @ Sierra College Blvd.	$44,214	$8,843	$11,054	N/A	N/A	$64,110
26	191	Miners Ravine @ Barton Road	$308,621	$61,724	$77,155	N/A	N/A	$447,500
27	199	Miners Ravine @ Auburn-Folsom Road	$108,500	$21,700	$27,125	N/A	N/A	$157,325
28	203	Miners Ravine @ Auburn-Folsom Road	$180,333	$36,067	$45,083	N/A	N/A	$261,483
29	207	Miners Ravine @ Dick Cook Road	$62,636	$12,527	$15,659	N/A	N/A	$90,822
30	208	Miners Ravine @ Auburn-Folsom Road	$100,966	$20,193	$25,242	N/A	N/A	$146,401
31	210	Miners Ravine @ Horseshoe Bar Road	$73,690	$14,738	$18,423	N/A	N/A	$106,851
32	212	Miners Ravine @ King Road	$62,133	$12,427	$15,533	N/A	N/A	$90,093
33	223	Miners R. Cavitt-Stallman Trib. @ Barton Rd.	$23,633	$4,727	$5,908	N/A	N/A	$34,268
34	225	Miners Ravine Lake @ Auburn-Folsom Rd.	$69,324	$13,865	$17,331	N/A	N/A	$100,520
35	235	Secret Ravine @ Brace Road		$0	$0	N/A	N/A	$0
36	245	Secret Ravine @ Brennans Road	$250,754	$50,151	$62,689	N/A	N/A	$363,593
37	246	Secret Ravine @ Rock Springs Road	$250,754	$50,151	$62,689	N/A	N/A	$363,593
38	249	Secret Ravine @ Newcastle Road	$260,399	$52,080	$65,100	N/A	N/A	$377,579
39	250	Secret Ravine @ Powerhouse Road	$140,648	$28,130	$35,162	N/A	N/A	$203,940
40	256	Sucker Ravine @ Rocklin Road	$62,133	$12,427	$15,533	N/A	N/A	$90,093
41	267	Secret Ravine @ King Road	$54,511	$10,902	$13,628	N/A	N/A	$79,041
42	293	Secret R. West Fork Penryn Trib. @ Gilardi	$166,044	$33,209	$41,511	N/A	N/A	$240,764
	Total, Bridge and Culvert Replacement							$7,641,152
	CHANNEL IMPROVEMENT, LEVEES, AND FLOODWALLS							
1	N/A	City of Roseville, Dry, Linda, and Cirby Creeks					N/A	$44,600,000
2	N/A	SAFCA, Dry Creek in Rio Linda					N/A	$12,400,000
3	N/A	Miners Ravine near Joe Rodgers Road	$276,296	$55,259	$69,074	$27,630	N/A	$428,259
	Total, Channel Improvements, Levees, and Floodwalls							$57,428,259
	TOTAL, ALL STRUCTURAL IMPROVEMENTS							$77,287,624

TABLE 5-3

COST ESTIMATES, NON-STRUCTURAL ALTERNATIVES

Item No.	Description	Cost	Contingency at 25%	Engineering & Admin. at 20%	Land Cost	Total Cost
	FLOODPLAIN MAPPING - 100 MILES					
1	Surveying and Mapping	$700,000	$175,000	N/A	N/A	$875,000
2	Flood Hydraulics	$300,000	$75,000	N/A	N/A	$375,000
3	Floodplain Delineation and Profile	$300,000	$75,000	N/A	N/A	$375,000
4	Reports and Miscellaneous	$100,000	$25,000	N/A	N/A	$125,000
	Floodplain Mapping Total					$1,750,000
	REGIONAL FLOOD WARNING AND DATA ACQUISITION SYSTEM					
1	Streamgage/Precipitation station, complete	$8,000	$2,000	N/A	N/A	$10,000
2	Streamgage/Precipitation station, complete	$8,000	$2,000	N/A	N/A	$10,000
3	Streamgage/Precipitation station, complete	$8,000	$2,000	N/A	N/A	$10,000
4	Streamgage/Precipitation station, complete	$8,000	$2,000	N/A	N/A	$10,000
5	Base Station, complete	$22,000	$5,500	N/A	N/A	$27,500
	Total, Regional Flood Warning and Data Acquisition System					$67,500
	TOTAL, ALL NON-STRUCTURAL IMPROVEMENTS					$1,817,500

Reinforced Concrete Box Culverts. Costs for reinforced concrete box culverts were developed in much the same way as for the corrugated metal pipes. The Means and Richardson standard cost manuals were used to determine material costs per linear foot of precast box culverts. Installation labor, imported materials, and pavement reconstruction were all determined the same as for CMPs.

Bridge Construction. Bridges, in this plan, were assumed to be structures that are free-span structures with minimal supports. Moreover, bridges were visualized as large, flat structures with paved surfaces, and were used when culverts would not provide sufficient hydraulic capacity or where an existing bridge had to be improved or replaced. The unit cost for estimating bridge construction was $94 per square foot. This included traffic control; temporary supports; excavation of the new channel section at the bridge and upstream and downstream; construction of new abutment; and construction of a deck extension on the bridge.

Unlined Channels. For this type of improvement, the unit cost for normal excavation was $5.00 per cubic yard which includes: equipment, labor, installation, and contractors overhead and profit. Excavated material was assumed to be trucked 3 miles one way for disposal.

Floodwalls. Floodwalls were assumed to be constructed of reinforced concrete block with an average height of three feet above ground. The total cost per foot for floodwalls is $37.50 and includes material, equipment and labor to install the floodwall.

Detention Basin Facilities. For this Flood Control Plan, detention basin facility costs consisted of foundation preparation, dam embankment and impervious core, internal filter material, embankment slope protection, emergency spillway, and outlet works. The unit costs for these items are discussed in the following paragraphs.

Foundation Preparation. Prior to construction of the embankment for a detention dam, it is necessary to strip the foundation area and prepare a cutoff trench down the axis of the dam. The unit cost for this excavation is $2.70 per cubic yard. This includes off-site disposal at a one-way distance of three miles.

Dam Embankment and Impervious Core. For the purpose of preparing the cost estimates, a standard detention dam cross section was developed. The embankment shell was assumed to have a top width of at least 10 feet with upstream embankment slope of 3:1 and a downstream embankment slope of 2.5:1. Embankment material was assumed to be available on-site, with an average haul distance of 3,000 feet. Cost for the embankment material, including excavation, hauling, and compaction is $3.35 per cubic yard.

The impervious core of the embankment has a top width of eight feet and 1:1 side slopes. Material for the impervious core is assumed to be obtained off-site at a distance of three miles. Cost for the impervious core including material, excavation, hauling, and compaction is $7.47 per cubic yard.

Internal Filter Material. A graded sand and gravel filter drain will be placed on the downstream side of the impervious core of the embankment. Cost for the filter drain including materials, hauling, and placing is $12.34 per cubic yard.

Embankment Slope Protection. Embankment slope protection for the upstream side of the dam is assumed to be sorted dredger tailings. The cost of dredger tailings, obtained off-site, was determined by asking suppliers in the area. Cost of this material, including hauling and placement is $11.14 per cubic yard. Slope protection for the downstream face of the dam is assumed to be hydroseeded vegetative cover.

Emergency Spillway. Because of the height and storage behind the proposed detention dams, they will fall under dam safety regulations that require that the emergency spillway for each of the detention dams be designed to pass the Probable Maximum Flood for the site. The magnitude of the PMF was determined using Creager's C equation with a C value of 30. Creager's equation relates the drainage area of a watershed to the PMF using the C coefficient. This C value was estimated by using the SPF values developed by the Corps of Engineers for several watersheds in the Dry Creek watershed. Using a value of twice the SPF for the PMF, the average C coefficient was found to be 28.

The emergency spillway width was determined using the PMF and the spillway equation:

$$Q = C * L * H^{1.5}$$

where:
Q = PMF discharge in cfs
C = Spillway coefficient = 3.2
L = Spillway width in feet
H = Dam freeboard = 5 feet

The cost of the spillway includes a 20-foot concrete spillway crest and excavation of the unlined remainder of the spillway through the abutment. The cost of the concrete spillway crest, including forming and placing the concrete, was estimated at $115 per foot of width. It was assumed that the majority of the spillway excavation would be used in the dam embankment, therefore only the cost of excavation was included as part of the spillway costs.

Outlet Works. The outlet works for the spillway will consist of reinforced concrete welded steel gasket pipes with upstream and downstream headwalls, cutoff collars, and a riprap lined stilling basin at the outlet. This type of pipe was chosen because the heads under which it will be operating might cause leakage of other types of pipes. This leakage could weaken the embankment of the detention dam and cause failure. The pipes were sized to provide the maximum required discharge for accommodating the 100-year flood. The riprap lined stilling basin was designed using criteria developed by the Federal Highway Administration. Prices for various sizes of riprap, to be used in stilling basins, were obtained from area suppliers. Costs for the outlet works are determined on a lump sum basis from the parameters discussed above.

Land Acquisition. For flood control alternatives such as detention facilities, channel improvement and floodwalls, it could be necessary to purchase land. Where project sites, especially detention basins, are located on public lands such as parks, it was assumed that there would be no significant cost associated with acquiring the use of the land. In the case of privately held land, it was assumed that the land would have to be purchased outright. It would be possible to invoke the right of condemnation to acquire a critical site, but the cost of method of land acquisition was considered to be the same as for outright purchase.

On the basis of data collected by a local real estate firm for the City of Roseville, the cost of land can vary widely throughout the watershed depending on the land use designation and development in the area. However, all of the lands that would need to be acquired for detention basins are currently in or next to the floodplain and can be assumed to be less than prime development land. Because of the preliminary nature of the cost estimates for the detention basins, it was determined that a land acquisition cost of $65,000 per acre would be used in the cost estimate.

Non-Structural Alternatives Cost Criteria

Floodplain Management. Floodplain management, as defined for the Dry Creek Watershed Flood Control Plan, involves two major aspects; floodplain mapping and enforcement of ordinances restricting the clearing of vegetation from major stream channels and floodplains.

Floodplain Mapping. For cost estimation purposes, the proposed floodplain mapping was assumed to be done to FEMA standards. Estimated costs for floodplain mapping were obtained through discussions with FEMA and from recent experience in conducting FEMA floodplain mapping in Miners Ravine. The costs per mile are:

• Surveying and Mapping	$7,000
• Flood hydraulics	$3,000
• Floodplain delineation and profile	$3,000
• Miscellaneous and reports	$1,000
Total cost per mile	$14,000

Channel and Floodplain Clearing. Enforcement of existing and future ordinances restricting the removal of vegetation from major stream channels and floodplains will require the services of one person full time to inspect all the major channels on an ongoing basis and report infractions of the ordinances. Without this level of support, substantial floodplain clearing will probably occur, with a resulting increase in flood flows.

Regional Flood Warning and Data Acquisition System. The costs for acquiring and installing additional stations for the flood warning system were obtained through discussions with the City of Roseville. The City currently has an extensive network of flood warning gages that would be integrated into the full Dry Creek Flood Warning System to go with the proposed new sites in the County. Approximate prices for flood warning equipment and installation are as follows:

Remote Station

• Streamgage/precipitation station complete:	$4,500
• Fittings:	$1,000
• Installation:	$2,500
Total per site:	$8,000

Base Station

• Receiver/decoder:	$3,500
• Base Station Computer:	$6,500
• Setup/installation:	$2,000
• Software	$10,000
Total for Base Station:	$22,000

Streamflow and precipitation monitoring is an important, ongoing function associated the flood warning and data acquisition system. It was estimated that a technician would be required full-time for three-fourths of each year to service the flood warning and data acquisition system and to conduct other data collection activities such as stream gaging.

IMPLEMENTATION ROLES

Flood Control District

The Placer County Flood Control and Water Conservation District will have the responsibility of administering the flood control plan developed as a result of this study. These responsibilities will include:

- Acting as the clearinghouse for the funds associated with regionally funded flood control projects and maintaining accountability for funds received and distributed;
- Review of the design of proposed local, on-site detention facilities, determination of requirements for in-lieu fees, and inspection during construction of the local detention facilities;
- The planning, design, construction, operation, and maintenance of the regional detention facilities;
- The maintenance and operation of the hydrologic computer models developed as part of this study;
- The maintenance and operation of the regional flood warning system;
- Administration of the floodplain mapping program including future conditions mapping and coordination with FEMA for needed map revisions;
- Coordination with developers and other jurisdictions to insure that development and general plans are consistent with the Flood Control Plan;
- If appropriate, collection of fees and assessments; and
- Developing specific local flood control plans for areas where development is or will be occurring.

Other Jurisdictions

Each of the other jurisdictions in the Dry Creek watershed will have to be responsible for administering certain aspects of the Dry Creek Watershed Flood Control Plan. In general these responsibilities will be related to the collection of fees, as well as the operation and maintenance of local detention facilities.

The activities described below for each of the other jurisdictions are preliminary, based on assumptions concerning the proposed funding plan and may change dependent on the specific details of final funding plan.

Placer County. Placer County would be responsible for implementing assessments and fees and forming a Mello-Roos District encompassing all properties to be developed in the Dry Creek watershed, in the County and outside of the incorporated cities. This Mello-Roos District will participate in a joint powers agreement with similar districts in the cities and in Sacramento County to fund flood control costs allocated to new development. Funds collected by the Mello-Roos District will be transferred to the Placer County Flood Control and Water Conservation District for distribution. Design, and construction of the Joe Rodgers Road Channel Improvement project will also be the responsibility of Placer County.

Sacramento County. The Sacramento County Water Agency, through SAFCA, will have responsibility for the funding, design, construction, and maintenance of the Rio Linda Levee and Channel Improvement Project. Sacramento County will have responsibility for forming a Mello-Roos District of all properties to be developed that are in the Dry Creek watershed and also in the County. This Mello-Roos District will participate in a joint powers agreement with similar districts in the cities and in Placer County to fund flood control costs allocated to new development. Funds collected by the Mello-Roos District will be transferred to the Placer County Flood Control and Water Conservation District for distribution.

Cities of Roseville and Rocklin and Town of Loomis. Each of these jurisdictions will have the responsibility to form a Mello-Roos District of all properties to be developed that are in the Dry Creek Watershed. These Mello-Roos Districts will participate in a joint powers agreement with similar districts in Placer and Sacramento Counties to fund flood control costs allocated to new development. Funds collected by the Mello-Roos District will be transferred to the Placer County Flood Control and Water Conservation District for distribution. Operation and maintenance of local detention basins required as part of this plan will also be the responsibility of each of the jurisdictions.

The City of Roseville will be responsible for the construction and maintenance of the Roseville Channel Improvement Project. Roseville will also need to maintain existing local detention basins within the City limits.

The City of Rocklin will be responsible for the funding, construction, and maintenance of the flood control improvements constructed as part of the Rocklin Redevelopment project. Rocklin will also be responsible for the operation and maintenance of local detention basins constructed by developers inside the City.

The Town of Loomis will be responsible for continuing its capital improvements program, specifically the replacing of undersized culverts and stream crossings.

CHAPTER 6
FUNDING ALTERNATIVES

This chapter of the Dry Creek Watershed Flood Control Plan addresses the various means available to obtain revenue for improvements, operations and maintenance (O&M), and management of regional flood control in the Dry Creek watershed. Methods available for collecting funds, e.g., taxes, fees, and assessments, and methods of addressing cash flow needs, e.g., bonds, are discussed. In this report, the term "funding" refers to the method of collecting funds; the term "financing" refers to methods of addressing cash flow needs. The means of allocating costs to individual property owners and the geographic variability of the allocation methodology are discussed in the next chapter.

For the purposes of this discussion, we will divide flood control services and their related costs into two categories:

- Services benefiting existing development, and
- Services necessitated by or benefiting new development.

New development is defined as any land use change or construction that takes place after the funding procedures recommended in this plan are adopted. Existing development includes all properties where no land use change or construction occurs and the portion of the properties on which new development occurs that is not affected by the construction.

Due in part to state law and in part to political realities, the funding and financing options available differ somewhat for these two categories. This section first presents the funding and financing options applicable to existing development, followed by those applicable to new development.

FUNDING OF IMPROVEMENTS BENEFITING EXISTING DEVELOPMENT

Due to the nature of the recommended facilities, long term revenue generation is required. Long term revenue generation is needed, in part, because it will take time to construct the facilities needed in the Dry Creek Watershed, but, primarily, long term revenue generation is needed to fund the ongoing costs of flood control. Flood control facilities will not work if they are built and forgotten. Effective flood control includes maintenance of flood control facilities, monitoring of flood events, planning for change, and ongoing enforcement of flood control polices, all of which require long term funding. A brief description of funding and financing methods for existing development is presented below; several of these methods can be utilized for new development also. Funding and financing methods described in this subsection include:

Funding Methods

- Benefit Assessments/Utility Fees
- General Funds
- Sales Tax
- Gas Taxes
- State and Federal Grants

Financing Methods

- Pay-as-You-Go
- State Revolving Fund
- Revenue Bonds
- Certificates of Participation
- Assessment District Financing

Funding Methods

Fees and/or taxes are necessary to pay for improvements regardless of whether the improvements are paid for directly from the fees as with pay-as-you-go financing, or the improvements are paid for up front as with debt financing.

Benefit Assessments/Utility Fees. Benefit assessments or utility fees, sometimes called service fees or user fees, consist of a fee imposed on each property in proportion to the service provided to that property. Benefit assessments or utility fees are generally used as a means of funding water and wastewater services, but they are also becoming increasingly common as a source of funds for flood control.

They are inherently flexible in that the agency can select any assessment method that equitably relates the amount charged to the service provided. Benefit assessments are usually included as a separate line item on the annual property tax bill sent to each property owner. Utility fees are usually billed on a monthly or bi-monthly interval. In other respects, benefit assessments, utility fees and service charges are essentially identical.

The Placer County Flood Control and Water Conservation District has the authority to collect a benefit assessment, but only after approval by a majority of the voters in the District. Any of the cities in the Dry Creek Watershed could collect utility fees for flood control. The required implementation steps, such as voter approval, are different for each city.

Money collected through a flood control benefit assessment or utility fee could only be used for flood control services. No government entity could spend any portion of that money for other purposes. This feature of benefit assessments and utility fees often makes them more politically acceptable than other taxes and fees.

General Funds. The general funds for the cities and counties have been the primary source of funds in the past for flood control in the Dry Creek watershed. General fund money comes largely from property taxes and sales taxes.

All the governments in the Dry Creek watershed face the same problem with their general funds; the need for money exceeds the supply available. This plan identifies a significant flood control funding need beyond that currently being provided by the cities and counties. It is unlikely that money could be made available from the cities' and counties' general funds to meet even a portion of that increased requirement.

Sales Tax. The primary advantage of the sales tax as a source of revenue is its broad taxing base. Other advantages are that such a tax allows the agency to keep pace with the economic growth of the community and it reflects price increases. The allocation of sales tax increases to finance the drainage program would raise significant revenues. Voter acceptance and approval of such an increase within both Placer and Sacramento Counties could be expected to require significant public relations and community involvement efforts to be successful. Sales tax increases have been approved by voters recently in the Bay Area and southern

California, but the revenues were raised for transportation improvements. It is doubtful that a sales tax increase for flood control would receive voter approval.

Gas Taxes. Many flood control problems relate to bridges and culverts. It is common to fund some or all of the construction and maintenance costs of bridges and culverts from gas taxes. The only drawbacks to this source of funds for flood control are that:

- Gas taxes can only be used for items, such as bridges and culverts, that relate to roads.

- Entities setting the spending priorities for gas tax funds do not generally have flood control as a high priority in their spending decisions. High priority projects from a flood control point of view may have a low priority from a transportation point of view and hence will be delayed or never constructed.

District Funding Authority. The legislation establishing the Placer County Flood Control and Water Conservation District specifically mentions that the District is authorized to utilize the following funding sources:

- Rates and charges for services provided by the district.
- Standby charges not to exceed ten dollars per acre or fraction thereof per year.
- Grants from the County General Fund authorized by the Board of Supervisors.
- Contracts with other agencies or districts.
- Benefit assessments.

"Rates and charges" as used in the legislation are a form of user fees. "Rates and charges" and "benefit assessments", as described in the legislation, differ primarily in the way each is enacted. Rates and charges as well as standby charges can be implemented by action of the Board of Directors of the district after specific notification procedures are followed. Benefit assessments require approval by a majority of the voters within the zone where the benefit assessment will be collected.

The legislation states that income from benefit assessments can be utilized for any district function, but it further lists several specific functions for which benefit assessments can be utilized. These include the following:

- Administration.
- Engineering.
- Construction.
- Operation and maintenance.
- Payment of principal and interest on special benefit bonds.

The Placer County counsel has issued an opinion that the listing in the legislation of specific functions for which benefit assessments can be utilized means that rates and charges cannot be used to fund those same functions.

County Service Area. Placer County has established a county service area that includes all of the unincorporated area of Placer County. One of the services the county service area is authorized to provide is drainage maintenance. The county service area collects fees and special taxes to fund the services it provides. Various state laws define the procedures that must be followed before new fees or taxes can be collected by the county service area. Legal advice should be obtained to precisely define procedures and authorities, should the county service area be selected as a desired funding mechanism for flood control.

Financing Methods

Debt financing is necessary if pay-as-you-go financing would not produce sufficient revenue within the needed time frame. Pay-as-you-go financing may be undesirable because it creates cash flow problems for public agencies and can be inequitable. Taxes and fees, as described above, are then used to repay the debt. Debt financing is only possible if a reliable source of funds is available to make regular debt payments.

Pay-As-You-Go Financing. Pay-As-You-Go financing involves periodic collection of capital charges or assessments from individuals within the municipality's jurisdiction for the purpose of funding future capital improvements. These revenues are accumulated in a capital reserve fund and some years later, are used for capital projects. Although this type of financing is not widespread, it has been successfully utilized by several large special districts in California. Pay-as-you-go financing can be used to finance 100 percent or only a portion of a given project. One of the primary advantages of pay-as-you-go financing is that it avoids the transaction costs (e.g., legal fees, underwriters' discounts, etc.) associated with debt financing alternatives such as revenue bonds.

There are two common problems associated with this method. First, it is difficult to raise the required capital within the allowable time period without charging existing users an unreasonably high rate. Second, it can result in inequities in that existing residents would be paying for facilities that would be utilized by and benefit future residents. This problem is compounded if these same residents are simultaneously paying debt service for the facilities they are currently using.

State Revolving Fund. The federal Clean Water Act provides for the creation of a State Revolving Fund Loan Program capitalized in part by federal funds. The Division of Loans and Grants at the State Water Resources Control Board oversees this program. This program provides loans for funding construction of publicly owned wastewater treatment works and for implementation of non-point source pollution control management programs. Future PCFC&WCD projects may be eligible. However, final policy on eligible storm water projects has not been developed.

Loans will be available at one-half of the interest rate that the State paid on the most recent sale of general obligation bonds. The amount of the loan will be determined by eligible capacity that is determined by considering appropriate peak flows. Costs incurred for future capacity needs for a certain number of years are allowed; the wastewater program allows for flow projections up to 40 years. Because of the low interest rates, this loan program warrants further investigation.

Revenue Bonds. Revenue bonds are historically the principal method of incurring long-term debt. This method of debt obligation requires specific non-tax revenues pledged to guarantee repayment. Because non-tax revenues, such as user charges, facility income, and other funds are the bond holder's sole source of repayment, revenue bonds are not considered general obligations of the issuer. Revenue bonds are secured solely by a pledge of revenues. Usually the agency's revenues are derived from the facility that the bonds are used to acquire, construct, or improve. There is no legal limitation on the amount of authorized revenue bonds that may be issued, but from a practical standpoint, the size of the issue must be limited to an amount where annual interest and principal payments are well within the revenues available for debt service on the bonds. Drainage facilities may not be in operation for several years so debt service payments for those years in which revenue is not available would have to be capitalized and included in the original bond issue. Revenue bond covenants generally include coverage provisions which require that revenue from fees minus operating expenses be greater than debt service costs.

Revenue bonds can be issued under the Revenue Act of 1941 by any city or county. This would require approval from a majority of voters.

Certificates of Participation. Certificates of participation provide long-term financing through a lease agreement that does not require voter approval. The legislative body of the issuing agency is required to approve the lease arrangement by a resolution. The lessor may be a redevelopment agency, a non-profit organization, a joint powers authority, a for-profit corporation or other agency. The lessee is required to make payments typically from revenues derived from the operation of the leased facilities. In the case of drainage improvements, revenues could come from zone-wide rates and charges. The amount financed may include reserves and capitalized interest for the period that facilities will be under construction.

One disadvantage with certificates of participation, as compared with revenue bonds, is that interest rates can be slightly higher than with revenue bonds due to the insecurity associated with the obligation to make lease payments. Certificates of participation are seldom used for flood control projects. Perhaps that is because flood control projects are not direct revenue generators. The lack of revenue generation makes it difficult to find buyers willing to purchase the certificates. While certificates of participation or some other form of short term borrowing are theoretically possible, they are not a likely source of financing for flood control in the Dry Creek watershed.

Assessment District Financing. Financing by this method involves initiating assessment proceedings. Assessment proceedings are documents in "Assessment Acts" and "Bond Acts". An assessment act specifies a procedure for the formation of a district (boundaries), the ordering and making of an acquisition or improvement, and the levy and confirmation of an assessment secured by liens on land. A bond act provides the procedure for issuance of bonds to represent liens resulting from proceedings taken under an assessment act. Procedural acts include the Municipal Improvements Acts of 1911 and 1913. The commonly used bond acts are the 1911 Act and the Improvement Bond Act of 1915. The procedure most prevalent currently is a combination of the 1913 Improvement Act with the 1915 Bond Act. Charges for debt service can be included as a special assessment on the annual property tax bill. The procedure necessary to establish an assessment district may vary depending on the acts under which it is established and the district size. In every case, some form of approval by the district residents and/or landowners is required.

District Financing Authority. The legislation establishing the Placer County Flood Control and Water Conservation District lists several financing vehicles that the district is authorized to use:

- Improvement bonds (This is the assessment district financing described above.)
- Special Benefit Bonds (This is a version of assessment district financing specially defined for the district)
- Revenue Bonds.
- Short-term borrowing (This would include certificates of participation. The term is limited to 5 years.)

FUNDING FOR IMPROVEMENTS BENEFITING NEW DEVELOPMENT

This section includes brief descriptions of the following methods used to fund and finance flood control improvements benefiting new development:

Funding Methods

- Development Charges/Connection Fees
- Developer-Provided Infrastructure
- Mello-Roos Community Facilities District

Financing Methods

- Proposition 46 General Obligation Bonds
- Mello-Roos Community Facilities District Bonds
- Marks-Roos Financing

All of the funding methods previously discussed for existing development, such as benefit assessments, are also applicable to new development. This section discusses additional funding options, available for new development, that are not readily available for existing development.

Funding Methods

As discussed previously, funds must be collected to pay off debt financing, to fund capital improvements and to pay operations and maintenance costs. In addition to the public funding options, it may be possible to require developers to finance improvements for new development. Some of the funding options available are discussed below.

Development Charges/Connection Fees. System development charges are similar to connection fees commonly charged to new development to hook up to water and wastewater systems. They are one-time fees charged to developers at the time of subdivision approval or building permit issuance. The charges for individual properties may be based on whatever assessment measures the agency desires for equity.

The development fee is generally applied on a unit cost basis with the acre used as the most common unit. Other units based on land uses and impervious surfaces can be used and may be more appropriate for drainage improvements. The charge must be based on a realistic definition of the scope, nature, and estimated cost of major drainage improvements planned for each subbasin. The fees may vary from subbasin to subbasin.

A disadvantage to utilizing drainage development charges is that they cannot be used to fund the correction of existing drainage problems in already developed areas. Another difficulty with impact fees is that the fees cannot be collected until the building permit stage at the earliest. The amount collected each year depends solely on the rate of development. Consequently, funds may not be available to construct new capacity at the time it is needed.

Developer-Provided Infrastructure. For developing areas with specific storm drainage system needs, each developer may be required to construct the regional infrastructure needed to accommodate the development of their lands. This approach is typical for improvements within the development project boundaries; it could be extended to off-site improvements also. When a developer constructs regional facilities, a development fee is frequently charged to other developments within the basin and the first developer is reimbursed.

Advantages of this method are that it is politically easy to implement and that only users benefiting from the improvements need to pay for them. The disadvantage is that the first developer in a basin must finance the costs of regional improvements, making the approach inequitable.

Mello-Roos Community Facilities District. The Mello-Roos Community Facilities Act was enacted by the California Legislature to provide an alternative method of funding and financing certain essential public facilities and services. It is directed especially to developing areas and areas undergoing rehabilitation.

Regarding facilities, the Community Facilities District may finance the purchase, construction, expansion, or rehabilitation of any real or other tangible property with an estimated useful life of five years or longer.

There is considerably more flexibility in the method of determining special taxes for a Mello-Roos District than under the assessment acts. Each property is allocated its responsibility for debt service according to a "special tax" formula (which must not be ad valorem). The formula may allow shifts in financial burden among the properties as they are split and developed according to various land uses. Existing and future development and inflation of costs may be considered in developing the method of determining taxes. Mello-Roos Districts are primarily intended to fund capital costs, but provisions in the legislation permit Mello-Roos Districts to fund certain ongoing costs including operations and maintenance of flood control facilities.

The greatest hindrance to community facilities district formation is the approval required by two-thirds of the registered voters or property owners. It is utilized best in developing areas in which there are still a minimal number of landowners.

Financing Methods

As discussed above under financing for existing development, pay-as-you-go financing may be undesirable because it creates serious cash flow problems. Financing can overcome cash flow problems and make an earlier project start possible

Proposition 46 General Obligation Bonds. Proposition 46, passed by the state's voters in 1987, allows a general obligation bond issue for a limited area. If over ten property owners are included, a formal election must be held. The costs of the project are allocated to the properties by assessed valuation throughout the life of the bonds, so no administrative cost is incurred to reallocate each year as property splits and combinations occur. One disadvantage is that there would be considerable inequity. Assessed valuation is not related to the benefit received.

Mello-Roos Community Facilities Bonds. If a Mello-Roos district is formed, Mello-Roos bonds can be sold to finance the necessary improvements.

Marks-Roos Financing. The Marks-Roos Local Bond Pooling Act of 1985 has proven to be one of the more useful and flexible financing devices. It expands the types of projects and programs that can be financed by joint powers authorities, facilitates regional projects and pool financing, and may offer significant economies of scale and convenience. Marks-Roos bonds generally refer to bonds issued by a joint powers authority to make loans to or entering financing leases with or acquire bonds from two or more public entities or to a single entity for more than one project. Starting in 1989, public entities in California have been making increasing use of Marks-Roos bonds.

Advantages of Marks-Roos bonds are the ability to lock in current interest rates, and the cost savings of financing multiple projects with one bond issue versus separate stand alone bond issues for each project's financing. Disadvantages include higher interest rates if rates decrease after bonds are issued, greater legal and administrative complexity and risk, and additional costs resulting from the complexity and size of the bonds if proceeds are not entirely used to acquire obligations.

SUMMARY

For existing development, benefit assessments are a good method for generating revenue irrespective of whether pay-as-you-go or a debt financing method is used to pay for the cost of improvements. Increasing the County sales tax would generate income but approval by the voters is not as likely as with benefit assessments. The State Revolving Fund loans should be investigated further for a low-cost form of debt financing. In addition, special benefit bonds or assessment district bonds may be appropriate for debt financing for improvements affecting existing developed areas. Certificates of Participation do not require voter approval but they do not appear to be readily applicable to financing flood control improvements.

For many individual on-site or semi-regional projects affecting newly developing areas, the most appropriate financing tool may be to require the developer to finance and construct the improvements. If the projects are more regional in nature, the most appropriate form of debt financing may be through Mello-Roos financing and perhaps Marks-Roos financing. Although it is not as common to do so, Mello-Roos could also be utilized for existing development. Existing land uses could be patterned into the tax formula so that developed properties with large runoff estimates would share a proportionately larger burden. Marks-Roos financing may be appropriate for joint venture projects and should be investigated further.

CHAPTER 7
PROPOSED FUNDING PLAN

INTRODUCTION

Chapter 6 presented several funding and financing options available for flood control. In this chapter, we select some of the more promising funding and financing options and develop some details on how they could be applied in the Dry Creek watershed.

Any funding plan should include the following elements:

- Cost of Service Estimate -- the amount of money needed.
- Revenue Flow -- when the money is needed and what methods, such as debt financing, are used to make that money available when it is needed.
- Definition of User Groups -- how the user population, i.e. the rate payers, are to be organized into groups for purposes of the funding plan.
- Estimation of User Group Size -- how big each user group is, based on a measure of size relevant to flood control. Impervious area is the most common measure of user group size for flood control funding plans.
- Cost Allocation -- how the costs are allocated to each user group.
- Billing Structure -- how costs are computed for each user.

This chapter presents information on each of the above funding plan elements as they apply to the Dry Creek watershed.

This funding plan primarily addresses the funds needed to serve new development. The Policy Advisory Committee (PAC) has defined a policy that new development shall pay all costs for flood control systems necessitated by that new development, including operations and maintenance. This funding plan discusses how those costs can be charged to new development and what amounts of money are needed for flood control services related to new development.

It is not possible at this time to develop all elements of a funding plan for flood control services to existing development. The PAC has not been able to select a means of collecting the needed funds from existing development that is politically acceptable. This plan presents a cost of service estimate for flood control services to existing development. The details for allocating those costs cannot be analyzed until a politically acceptable allocation method has been selected.

COST OF SERVICE

For the purposes of this analysis, we have organized the costs related to providing flood control services into two major categories and have then subdivided those major categories into a number of smaller categories. The two major cost categories are "First Costs" and "Ongoing Costs". "First Costs" are costs that occur one time only. Principal among them are the capital costs to construct a new facility. "Ongoing Costs" are those costs that continue year after year. The most common "Ongoing Cost" is maintenance of the flood control facilities.

First Costs

We have examined several different categories of "First Costs". The following paragraphs present a discussion of each of these cost categories.

Regional Detention. In the Facilities Plan portion of this project, seven regional detention basins were recommended. Each of these regional detention basins receives runoff from a large portion of the watershed and contributes significantly to reducing flood flows on the main stem of Dry Creek. Each detention basin also reduces the peak flow in the tributary on which it is located. The total "first cost" for these detention basins is estimated to be $11,700,000.

Bridges, Culverts, and Channel Improvements. Hydrologic analyses showed that a large number of culverts and bridges were undersized and that channel improvements were needed in certain areas. The recommended facilities plan calls for certain of these bridges, culverts and channels to be improved at a total cost of $7,700,000.

SAFCA Improvements. The Sacramento Area Flood Control Agency (SAFCA) is working on a plan for channel and levee improvements in the lower reaches of Dry Creek. Estimates available at this time place the cost of these improvements at $44,600,000. SAFCA expects that federal and state agencies will $34,000,000 of that cost.

Roseville Improvements. The City of Roseville is also developing plans for channel improvements through the City of Roseville. Those improvements are expected to cost $12,400,000.

Local Detention Basins. This Master Plan recommends that each new development construct a detention basin to keep peak flow after development no greater than peak flow before development. It is not possible to accurately estimate the total cost of these local detention basins. By analyzing some "typical" development examples, JMM has estimated "typical" construction costs for a local detention basin and the land area required. These estimates are used in the local detention rate structure discussed later in this chapter.

Local Storm Drainage Conveyance Systems. This funding plan does not address these local conveyance systems.

Master Plan. This master plan cost approximately $200,000 to prepare, including consultant fees and time for Flood Control District staff and staffs from several cities.

Payback to Cities. Regional flood control work accomplished to date by the Flood Control and Water Conservation District has been funded by the cities and the County. The intent has always been that a portion of those funds would be repaid once an independent source of funds was secured for the District. For purposes of the funding plan, it has been assumed that $200,000 of the funds contributed by the cities and Placer County is to be repaid. Half of that loan, or $100,000, is to be repaid by property owners in the Dry Creek watershed. The remainder of the loan is to be repaid by properties outside the Dry Creek watershed. It should be noted that $200,000 is not the full amount of the funds given to the District by the cities and County, but only the portion assumed to be a loan.

Right-of-Way Purchase. The regional flood control system can only be properly managed if the governments involved have the right of access to the streams, culverts, bridges, and related system components. Right of access can only be assured if rights-of-way or easements are held by the responsible governmental entity such as the Flood Control District.

Some property owners may be willing to donate easement rights to the District, but others will not. This item is an estimate of the cost of purchasing easements along Dry Creek and its major tributaries. This item does not include purchasing property for detention basins. Detention basin property acquisition is included in the detention basin costs.

ALERT Equipment. The plan recommends that Placer County expand the current flood warning and monitoring system. The costs to acquire and install additional monitoring equipment comprise this item.

Ongoing Costs

James M. Montgomery, Consulting Engineers, Inc. (JMM) worked with the Placer County Flood Control and Water Conservation District during 1988 to develop the information needed for the District to implement a benefit assessment. The District Board decided not to adopt a benefit assessment and the work was never published. Included in the information prepared during that work was an estimate of the "ongoing costs" associated with regional flood control management in Placer County.

The estimates of "ongoing costs" developed during the 1988 benefit assessment work are used here with appropriate adjustments. The original estimates have been increased by 12% to account for inflation. The estimates have also been decreased by 50% since the 1988 work applied to all Placer County and this work applies only to the Dry Creek watershed, roughly half the 1988 study area.

Ongoing costs can be expected to change over time due to inflation and changes in the services provided. Several of the available funding mechanisms, such as benefit assessments and Mello-Roos Districts, have provisions for periodic review and adjustment of fees to reflect changes in the costs of ongoing services.

Administration. This category covers the time spent by Placer County public works management and clerical staff associated with regional flood control.

Insurance. This is an estimate of the cost of insuring the District against liability claims resulting from flood damages.

Reserve. This is a recommended amount for unidentified flood control costs.

Engineering. This item includes the time for the District Engineer and two Associate Engineers.

Monitoring/Warning. This item includes the cost of maintaining and operating the ALERT flood warning system and conducting an ongoing stream monitoring program. This item was included in the 1988 work, but new analysis suggests that the 1988 estimates were inadequate. This item was increased to be adequate to cover half the cost of one person's time plus equipment maintenance. It is assumed that the other half of that person's time would be spent on monitoring tasks outside the Dry Creek watershed.

Water Quality Studies. This item is to cover costs related to water quality monitoring and permitting.

Maintenance. Regional flood control maintenance consists primarily of maintaining channels, bridges, culverts, and regional detention basins. Channel maintenance was the largest single item in the 1988 estimate. The analyses done for this plan have demonstrated that channel maintenance in the Dry Creek watershed should be limited. Extensive channel and floodplain clearing would speed runoff and increase downstream flooding. Thus a low level of channel maintenance is recommended. To account for the low level of channel maintenance, the maintenance cost figure from the 1988 work was reduced by 30% (in addition to the general adjustments applied to every category).

Detention Basin Maintenance. The regional detention basins will require regular maintenance if they are to remain effective for flood control. Maintenance costs will depend in part on the design of each detention basin. As a preliminary estimate, maintenance costs have been estimated at $10,000 per year per regional detention basin.

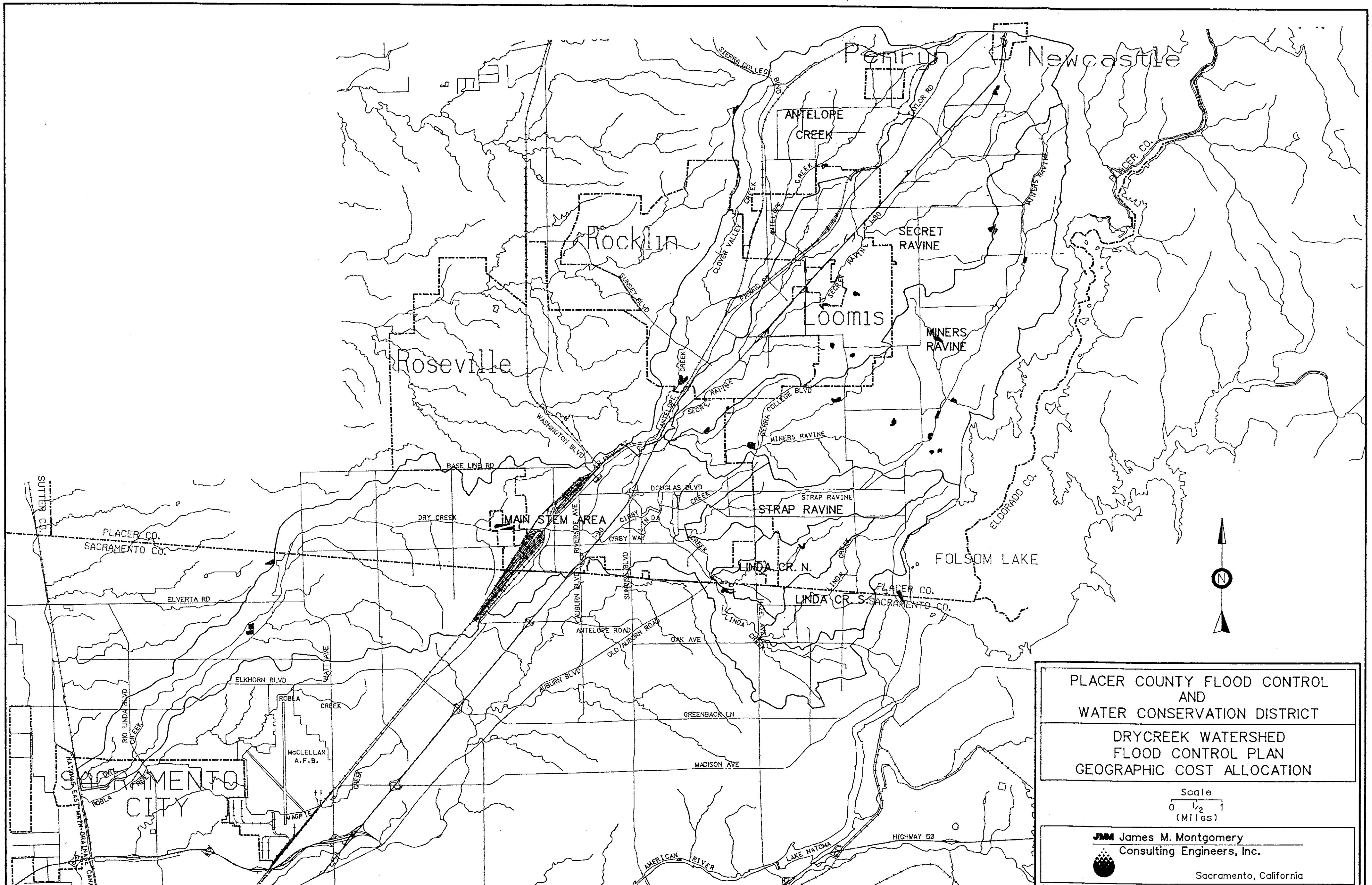
Floodplain Mapping. Development of flood control improvements will alter the floodplain boundaries in the Dry Creek watershed. It is recommended that floodplain maps be updated regularly to account for these changes. Floodplain mapping can be an ongoing task with a portion of the channels analyzed each year. The funding plan assumes that ten percent of the approximately 100 miles of major stream channels in the Dry Creek watershed will be analyzed each year. The plan estimates a unit cost for floodplain mapping of $17,500 per mile, which includes and 25% contingency. Thus, the annual cost for floodplain mapping is estimated to be $175,000.

GEOGRAPHIC COST ALLOCATION

Some flood control facilities serve the entire Dry Creek watershed. Other facilities serve only one of the tributaries. The purpose of the geographic cost allocation is to distribute costs to geographic areas so the residents feel they are paying only for those facilities that serve them. There are an infinite number of ways to divide the Dry Creek watershed. We propose the geographic subdivision shown in Figure 7-1. This proposed geographic subdivision includes an area for the main stem and then an area for each of six tributaries. The six tributary areas are: Linda Creek South, Linda Creek North, Secret Ravine, Miners Ravine, Strap Ravine, and Antelope Creek.

The following allocation of costs to these geographic areas is proposed:

- Regional detention basin costs are to be allocated to the entire Dry Creek watershed.
- Costs for culverts, bridges, and channel improvements along the main stem are to be allocated to the entire Dry Creek watershed.
- Costs for culverts, bridges, and channel improvements along a tributary are to be allocated to that tributary area only.
- Costs for the channel improvements recommended by Roseville are to be allocated to the entire Dry Creek watershed.
- None of the costs for the channel and levee improvements recommended by SAFCA are to be allocated to Placer County.
- Master plan preparation costs are to be allocated to the entire Dry Creek watershed.
- The payback to the Cities is to be allocated to the entire Dry Creek watershed.
- Right-of-Way acquisition costs are to be allocated to the entire Dry Creek watershed.



Penryn
Newcastle
ANTELOPE CREEK
Rocklin
SECRET RAVINE
Loomis
MINERS RAVINE
Roseville
MAIN STEM AREA
STRAP RAVINE
LINDA CR. N.
LINDA CR. S.
FOLSOM LAKE
PLACER CO.
SACRAMENTO CO.
SUTTER CO.
ELDORADO CO.
SACRAMENTO CITY
McCLELLAN A.F.B.
BASE LINE RD
DRY CREEK
ELVERTA RD
ELKHORN BLVD
ANTELOPE ROAD
OAK AVE
GREENBACK LN
MADISON AVE
AUBURN BLVD
OLD AUBURN ROAD
DOUGLAS BLVD
SIERRA COLLEGE BLVD
WASHINGTON BLVD
SUNSET BLVD
HIGHWAY 50
AMERICAN RIVER
LAKE NATOMA
PLACER COUNTY FLOOD CONTROL
AND
WATER CONSERVATION DISTRICT
DRYCREEK WATERSHED
FLOOD CONTROL PLAN
GEOGRAPHIC COST ALLOCATION
Scale
0 1/2 1
(Miles)
JMM James M. Montgomery
Consulting Engineers, Inc.
Sacramento, California

FIGURE 7-1

- Costs for acquisition and installation of the ALERT system are to be allocated to the entire Dry Creek watershed.

- All "ongoing costs" are to be allocated to the entire Dry Creek watershed.

Some discussion is necessary regarding the allocation of costs for the Roseville and SAFCA improvements. These improvements are being planned by specific agencies within the Dry Creek Watershed, but a case could be made for regional participation in the funding of these improvements.

The Roseville improvements are on the main stem of Dry Creek or on the tributaries to Dry Creek near their confluence with the main stem. They are needed to address frequent flooding of these channel in the City of Roseville. One viewpoint is that flow from most of the watershed contributes to the channels in Roseville. From that point of view, all of the costs for channel improvement in Roseville should be allocated to the entire watershed. A different viewpoint is that development near the channels in Roseville has made flood protection necessary, and thus, only people in Roseville should pay for the channel improvements. The selection of one of these two viewpoints is a policy choice that must be made by the people in the Dry Creek Watershed. In this funding plan, the Roseville improvement costs have been allocated to the entire watershed.

Similar points can be made regarding funding of the improvements recommended by SAFCA. One factor makes the SAFCA improvements different -- SAFCA has already developed a funding plan. That funding plan assumes no participation from Placer County in funding the channel and levee improvements in Sacramento County. Given that fact, the cost of service analysis for this funding plan assumes that residents of Placer County. will fund none of the cost for the SAFCA improvements.

ALLOCATION OF COSTS TO NEW AND EXISTING DEVELOPMENT

The Policy Advisory Committee has set the policy that all costs necessitated by new development are to be allocated to new development. The remaining costs shall be paid by all landowners. The following approach to allocating costs to new and existing development is proposed.

Regional Detention Basins

The cost to build sufficient regional detention basin capacity to keep peak downstream flows at or below present levels is to be allocated to new development. The remaining cost necessary to make those detention basins the sizes recommended in this plan is to be allocated to all landowners.

Bridges, Culverts, and Channel Improvements

The cost to improve bridges, culverts, and channels is to be allocated to new development and existing development. The allocation formula is based on the amount the peak flow at the subject improvement exceeds the existing facility capacity. For example, consider an existing bridge with the following characteristics:

- Current bridge flow capacity 1,000 cfs
- Current peak flow to the bridge 1,200 cfs
- Peak flow to the bridge at buildout 1,600 cfs

$$\text{Fraction allocated to new development} = \frac{1{,}600 \text{ cfs} - 1{,}200 \text{ cfs}}{1{,}600 \text{ cfs} - 1{,}000 \text{ cfs}}$$

$$= 2/3$$

SAFCA and Roseville Improvements

With regional detention, the flows in the main stem of Dry Creek, even after build-out, will be less than they are now. Without regional detention, future development will cause flood flows in Dry Creek to increase. While this plan recommends that regional detention be constructed, there is no guarantee the detention basins will ever be built. Given this uncertainty, SAFCA and Roseville have planned flood control improvements in their respective areas assuming none of the regional detention recommended in this plan is built. This plan recommends that new development be required to fund its share of the cost of building regional detention basins. It is not reasonable, and probably not legal, to also charge new development a portion of the cost of the SAFCA and Roseville improvements. Thus this plan allocates none of the cost of the Roseville and SAFCA improvements to new development.

Should the regional detention basins not be built, the money collected for them could and should be used to pay a portion of the cost for the Roseville and SAFCA improvements.

Master Plans

All of the cost of preparing master plans should be allocated to new development.

Payback to Cities

A large percentage of the work of the Flood Control District over the past several years has been in developing policies and plans to be applied to new development. The District's work over the past several years has been funded by loans from the cities. It is reasonable to allocate a portion of the loan payback to new development. The District has not distinguished between costs related to new development and those related to existing development in their accounting records. Thus it is not possible to develop a precise figure for the portion of the loan payback that should be assessed to new development. Lacking a more accurate figure, this plan suggests that 50% of the loan payback be allocated to new development.

Right-of-Way Purchase

It is probable that any easements needed in developing areas will be donated to the appropriate government. Easements will only need to be purchased in already developed areas. Thus none of the right-of-way purchase costs should be allocated to new development.

ALERT Equipment

Acquisition costs for the extension of the existing ALERT system should be allocated to existing development.

TABLE 7-1

COST ALLOCATION TO NEW AND EXISTING DEVELOPMENT BY GEOGRAPHIC ARE

	Entire Dry Creek Watershed			Linda Cr. South			Linda Cr. North			Strap Ravine		
Item No.	Total Flow Cost	New Dev Cost	Exist Dev Cost	Total Flow Cost	New. Dev Cost	Exist Dev Cost	Total Flow Cost	New Dev. Cost	Exist Dev Cost	Total Flow Cost	New Dev. Cost	Exist Dev Cost
	BRIDGE AND CULVERT REPLACEMENTS											
1	$195,782	$75,854	$119,928			$0			$0			$0
2	$223,750	$85,284	$138,465			$0			$0			$0
3	$89,649	$52,200	$37,450			$0			$0			$0
4	$1,491,667	$215,434	$1,276,233			$0			$0			$0
5	$309,987	$82,374	$227,613			$0			$0			$0
6	$387,833	$74,703	$313,130			$0			$0			$0
7	$67,570	$26,388	$41,182			$0			$0			$0
8	$51,403	$4,582	$46,821			$0			$0			$0
9	$98,499	$8,780	$89,719			$0			$0			$0
10	$33,148	$16,759	$16,389			$0			$0			$0
11	$108,112	$41,774	$66,338			$0			$0			$0
12	$33,148	$19,295	$13,853			$0			$0			$0
13	$431,185	$113,762	$317,423			$0			$0			$0
14			$0	$150,155	$32,240	$117,915			$0			$0
15			$0	$26,277	$12,820	$13,457			$0			$0
16	$101,947	$51,372	$50,575			$0			$0	$101,947	$51,372	$50,575
17			$0			$0	$56,826	$16,563	$40,262			$0
18			$0			$0			$0			$0
19			$0			$0			$0			$0
20			$0			$0			$0			$0
21			$0			$0			$0			$0
22			$0			$0			$0			$0
23			$0			$0			$0			$0
24			$0			$0			$0			$0
25			$0			$0			$0			$0
26			$0			$0			$0			$0
27			$0			$0			$0			$0
28			$0			$0			$0			$0
29			$0			$0			$0			$0
30			$0			$0			$0			$0
31			$0			$0			$0			$0
32			$0			$0			$0			$0
33			$0			$0			$0			$0
34			$0			$0			$0			$0
35			$0			$0			$0			$0
36			$0			$0			$0			$0
37			$0			$0			$0			$0
38			$0			$0			$0			$0
39			$0			$0			$0			$0
40			$0			$0			$0			$0
41			$0			$0			$0			$0
42			$0			$0			$0			$0
TOTAL	$3,623,679	$868,561	$2,755,118	$176,432	$45,060	$131,372	$56,826	$16,563	$40,262	$101,947	$51,372	$50,575
	JOE RODGERS ROAD CHANNEL IMPROVEMENTS											
			$0			$0			$0			$0
	REGIONAL DETENTION BASINS											
RDB1	$1,416,911	$1,084,138	$332,773			$0			$0			$0
RDB4	$1,124,017	$595,464	$528,553			$0			$0			$0
RDB6	$530,395	$534,811	$0			$0			$0			$0
RDB7	$6,288,317	$1,381,563	$4,906,753			$0			$0			$0
RDB9	$256,924	$200,115	$56,809			$0			$0			$0
RDB12	$168,583	$144,217	$24,365			$0			$0			$0
RDB16	$2,433,068	$1,195,151	$1,237,917			$0			$0			$0
TOTAL	$12,218,215	$5,135,459	$7,082,755			$0			$0			$0
	SAFCA CHANNEL IMPROVEMENTS											
	$44,600,000	$0	$0			$0						$0
	ROSEVILLE CHANNEL IMPROVEMENTS											
	$12,400,000	$0	$12,400,000			$0						$0
	MASTER PLAN											
	$200,000	$200,000	$0			$0			$0			$0
	PAYBACK											
	$100,000	$50,000	$50,000			$0			$0			$0
	RIGHT OF WAY PURCHASE											
	$500,000	$0	$500,000			$0			$0			$0
	REGIONAL FLOOD WARNING AND DATA ACQUISITION SYSTEM											
	$67,500	$0	$67,500									
TOTAL	$73,709,394	$6,254,020	$22,855,373	$176,432	$45,060	$131,372	$56,826	$16,563	$40,262	$101,947	$51,372	$50,575
	TOTAL FIRST COSTS FOR ALL BASINS											
	$78,257,072	$7,450,053	$26,207,019									
	ONGOING COSTS (ANNUAL COSTS)											
	$977,728	$0	$977,728									

TABLE 7-1 (Continued)

	Miners Ravine			Secret Ravine			Antelope Creek		
Item No.	Total Flow Cost	New Dev. Cost	Exist Dev Cost	Total Flow Cost	New Dev. Cost	Exist Dev Cost	Total Flow Cost	New Dev. Cost	Exist Dev Cost
	BRIDGE AND CULVERT REPLACEMENTS								
1			$0			$0			$0
2			$0			$0			$0
3			$0			$0			$0
4			$0			$0			$0
5			$0			$0			$0
6			$0			$0			$0
7			$0			$0			$0
8			$0			$0			$0
9			$0			$0			$0
10			$0			$0			$0
11			$0			$0			$0
12			$0			$0			$0
13			$0			$0			$0
14			$0			$0			$0
15			$0			$0			$0
16			$0			$0			$0
17			$0			$0			$0
18			$0			$0	$0	$0	$0
19			$0			$0	$51,403	$19,978	$31,425
20			$0			$0	$34,268	$20,467	$13,801
21			$0			$0	$15,992	$4,445	$11,547
22			$0			$0	$279,688	$24,383	$255,305
23			$0			$0	$139,844	$32,035	$107,809
24			$0			$0	$45,047	$10,461	$34,586
25	$64,110	$18,336	$45,774			$0			$0
26	$447,500	$95,802	$351,698			$0			$0
27	$157,325	$58,597	$98,728			$0			$0
28	$261,483	$73,350	$188,133			$0			$0
29	$90,822	$23,204	$67,618			$0			$0
30	$146,401	$40,321	$106,079			$0			$0
31	$106,851	$28,742	$78,108			$0			$0
32	$90,093	$19,282	$70,811			$0			$0
33	$34,268	$12,454	$21,814			$0			$0
34	$100,520	$23,945	$76,575			$0			$0
35			$0	$0	$0	$0			$0
36			$0	$363,593	$63,894	$299,699			$0
37			$0	$363,593	$63,557	$300,036			$0
38			$0	$377,579	$111,141	$266,438			$0
39			$0	$203,940	$61,206	$142,734			$0
40			$0	$90,093	$30,126	$59,967			$0
41			$0	$79,041	$25,213	$53,828			$0
42			$0	$240,764	$130,366	$110,398			$0
TOTAL	$1,499,373	$394,034	$1,105,339	$1,718,602	$485,503	$1,233,099	$566,241	$111,768	$454,473
	JOE RODGERS ROAD CHANNEL IMPROVEMENTS								
	$428,258	$91,733	$336,525			$0			$0
	REGIONAL DETENTION BASINS								
RDB1			$0			$0			$0
RDB4			$0			$0			$0
RDB6			$0			$0			$0
RDB7			$0			$0			$0
RDB9			$0			$0			$0
RDB12			$0			$0			$0
RDB16			$0			$0			$0
TOTAL			$0			$0			$0
	SAFCA CHANNEL IMPROVEMENTS								
			$0			$0			$0
	ROSEVILLE CHANNEL IMPROVEMENTS								
			$0			$0			$0
	MASTER PLAN								
			$0			$0			$0
	PAYBACK								
			$0			$0			$0
	RIGHT OF WAY PURCHASE								
			$0			$0			$0
	REGIONAL FLOOD WARNING AND DATA ACQUISITION SYSTEM								
TOTAL	$1,927,631	$485,767	$1,441,864	$1,718,602	$485,503	$1,233,099	$566,241	$111,768	$454,473

TABLE 7-2

FIRST COSTS ALLOCATED TO NEW DEVELOPMENT BY GEOGRAPHIC AREA

Cost Element	Entire Watershed	Linda Cr. S	Linda Cr. N.	Strap Rav	Miners Rav	Secret Rav	Antelope Cr
FIRST COSTS							
Regional Detention	$5,135,459						
Bridges, Culverts, & Channels	$868,561	$45,060	$16,563	$51,372	$485,767	$485,503	$111,768
SAFCA Improvements	$0						
Roseville Improvements	$0						
Master Plan	$200,000						
Payback Loan to Cities	$50,000						
R.O.W. Purchase							
ALERT Equipment	$0						
Bond Sale Costs	$223,502						
Total Revenue Need	$6,477,522	$45,060	$16,563	$51,372	$485,767	$485,503	$111,768

ANNUAL COSTS ALLOCATED TO ALL LANDOWNERS BY GEOGRAPHIC AREA

TABLE 7-3

Cost Element	Entire Watershed	Linda Cr. S	Linda Cr. N.	Strap Rav	Miners Rav	Secret Rav	Antelope Cr
FIRST COSTS							
Regional Detention	$722,441						
Bridges, Culverts, & Channels	$281,022	$13,400	$4,107	$5,159	$147,070	$125,776	$46,356
SAFCA Improvements	$0						
Roseville Improvements	$1,264,800						
Master Plan	$0						
Payback Loan to Cities	$5,100						
R.O.W. Purchase	$51,000						
ALERT Equipment	$6,885						
Bond Sale Costs	$80,193						
ONGOING COSTS							
Administration	$52,080						
Insurance	$112,000						
Reserve	$11,200						
Engineering	$166,320						
Monitoring/Warning	$41,800						
Water Quality Studies	$22,400						
Maintenance - General	$326,928						
Detention Basin Maintenance	$70,000						
Floodplain Mapping	$175,000						
TOTAL REVENUE NEED	$3,389,170	$13,400	$4,107	$5,159	$147,070	$125,776	$46,356
Cap. Recovery Factor	0.102						

presented in Table 7-3 include first costs and ongoing (operations and maintenance) costs. The cost figures in Table 7-3 are presented in terms of annual costs including debt retirement on first cost plus ongoing costs. Costs in Table 7-2 are presented as first costs while costs in Table 7-3 are presented as annual costs.

RECOMMENDED RATE STRUCTURE

There are an infinite number of ways a rate structure to collect the needed funds for flood control can be constructed. The following is a detailed development of one of those ways. The rate structure described here has been selected based on extensive input from representatives of local government staffs and policy makers in the watershed. The rate structure includes the following assumptions:

- All costs allocated to new development will be collected via development fees collected at the time building permits are issued.

- Bond financing will be used for all capital costs as described in the cost of service analysis.

- All costs allocated to existing development will be collected via a benefit assessment or user fee.

User Groups

The next step in the funding plan development requires that we divide the properties in the watershed into "user groups". These are groups of properties that will be treated similarly for purposes of the rate structure. User groups based on land use make the most sense for flood control rate structures. Land use categories similar to those used for the hydrologic analysis should be used, although they can be simplified somewhat. The following user groups are proposed:

- Commercial/Industrial
- High Density Residential
- Single Family Residential

For existing development, properties have been categorized into a user group based on the current land use. For new development, user group sizes were estimated based on the land use permitted in the applicable general plan.

Commercial/Industrial. This includes all privately owned businesses, all publicly owned buildings and similar facilities such as schools, and all non-profit buildings such as churches.

High Density Residential. This is all residential property with more than 4 dwelling units per acre. It includes condominiums, apartments, mobile homes, and high density single family complexes.

Single Family Residential. This is all residential property with 4 dwelling units per acre or less. This includes most single family lots as well as rural residential properties.

User Group Sizes

Some measure of user group size is needed as a basis for allocating costs to that user group. With flood control, the most commonly used measure of user group size is impervious area. For the portion of the funding plan applying to new development, the appropriate measure of user group size is the increase in impervious area in each user group. In other words, an estimate is needed of the amount of existing impervious area and the increase in impervious area to be expected in each of the three land use categories. Those estimates can be readily extracted from the hydrologic computations prepared for this flood control plan.

Cost Allocation to User Groups

Costs should be allocated to each user group based on the size of that group. More of the costs should be allocated to groups with more existing impervious area or greater projected increases in impervious area. Tables 7-4 and 7-5 present the area-specific unit costs for each user group given the revenue need allocations from Tables 7-2 and 7-3.

Billings

The next step is to calculate the billing to each property within a user group. That billing should be based on some readily measurable characteristic of the property. It is proposed that billings to commercial and industrial properties be based on property size(i.e. the gross acreage), and billings to all residential properties be based on the number of dwelling units. In other words, all single family homes would pay the same amount. All high density residences would pay based on the number of dwelling units on the property. The number of residences in the high density residential user group was estimated assuming there are or will be 7 residences per acre on average. The number of residences in the single family residential user group was estimated assuming the following number of residences per acre:

Land Use Category	Residences per Acre
Medium Density Residential	3
Low Density Residential	1.54
Rural Low Density Residential	0.667
Rural Residential/Rural Estates	0.286

Table 7-6 and 7-7 present the billings that result from this recommended billing structure.

Local Detention

As described in Chapter 5, most developers in the areas shown on Figure 5-2 will be required to construct local detention basins as a condition of development. In some cases, however, there will be reasons that a local detention basin should not be constructed by the developer. These situations will include developments where the topography does not permit construction of the detention basin and developments that are too small to make a detention basin practical. Exceptions to the local detention requirements will be determined on a case-by-case basis.

When local detention is not provided, some other means of compensating for the lack of that detention is needed. This could include the construction of a larger local detention watershed at another location to serve several developments, construction of a regional detention watershed, or increasing the size of the downstream conveyance system to handle the higher

TABLE 7-4

AREA-SPECIFIC UNIT COSTS RELATED TO NEW DEVELOPMENT

Basin	General Revenue Need (3)	General Impervious Area Increase (Sq. Mi.) (2)	Unit General Cost (1)	Basin Specific Revenue Need (3)	Basin Impervious Area Increase (Sq. Mi.) (2)	Unit Basin Specific Cost (1)	Unit Basin Total Cost (1)
Main Stem	$6,477,522	7.82	$828,848	$0	2.89	$0	$828,848
Linda Cr. S.	$6,477,522	7.82	$828,848	$45,060	0.26	$174,871	$1,003,718
Linda Cr. N.	$6,477,522	7.82	$828,848	$16,563	0.26	$63,667	$892,515
Strap Rav.	$6,477,522	7.82	$828,848	$51,372	0.48	$107,818	$936,666
Miners Rav.	$6,477,522	7.82	$828,848	$485,767	0.97	$502,811	$1,331,659
Secret Rav.	$6,477,522	7.82	$828,848	$485,503	2.26	$214,521	$1,043,369
Antelope Cr.	$6,477,522	7.82	$828,848	$111,768	0.70	$160,059	$988,907

NOTE:
1. Unit Cost in each case refers to cost per square mile of impervious area increase.
2. Impervious area estimate reduced to 85% of actual estimate to make the rates conservative to allow for estimating inaccuracies.
3. Revenue needs are all first costs (i.e. capital costs).

TABLE 7-5

AREA-SPECIFIC UNIT COSTS RELATED TO ALL LANDOWNERS

Basin	General Revenue Need (3)	General Impervious Area (Sq. Mi.) (2)	Unit General Cost (1)	Basin Specific Revenue Need (3)	Basin Impervious Area (Sq. Mi.) (2)	Unit Basin Specific Cost (1)	Unit Basin Total Cost (1)
Main Stem	$3,389,170	11.23	$301,773	$0	6.17	$0	$301,773
Linda Cr. S.	$3,389,170	11.23	$301,773	$13,400	0.37	$35,815	$337,588
Linda Cr. N.	$3,389,170	11.23	$301,773	$4,107	0.12	$32,959	$334,732
Strap Rav.	$3,389,170	11.23	$301,773	$5,159	0.46	$11,165	$312,939
Miners Rav.	$3,389,170	11.23	$301,773	$147,070	1.05	$140,011	$441,784
Secret Rav.	$3,389,170	11.23	$301,773	$125,776	1.68	$74,980	$376,753
Antelope Cr.	$3,389,170	11.23	$301,773	$46,356	1.37	$33,864	$335,638

NOTE:

1. Unit Cost in each case refers to cost per square mile of impervious area.
2. Impervious area estimate reduced to 85% of actual estimate to make the rates conservative to allow for estimating inaccuracies.
3. Revenue needs are all annual costs (debt retirement plus ongoing costs).

TABLE 7-6

DEVELOPMENT FEES FOR NEW DEVELOPMENT

User Group	Impervious Area Increase in User Group (Sq. Mi.)	Revenue Need Allocated to User Group	Billing Unit	No. Billing Units In User Group	Development Fee Per Unit
MAIN STEM					
SFR	1.35	$1,118,652	Dwelling Unit	7340	$152
HDR	0.43	$355,579	Dwelling Unit	3203	$111
Comm/Ind	1.63	$1,346,979	Gross Acres	1,155.64	$1,166
LINDA CREEK SOUTH					
SFR	0.29	$287,256	Dwelling Unit	1454	$198
HDR	0.01	$6,807	Dwelling Unit	51	$134
Comm/Ind	0.01	$10,210	Gross Acres	7.23	$1,411
LINDA CREEK NORTH					
SFR	0.30	$265,986	Dwelling Unit	1582	$168
HDR	0.00	$0	Dwelling Unit	0	$0
Comm/Ind	0.01	$7,178	Gross Acres	5.72	$1,255
STRAP RAVINE					
SFR	0.23	$212,899	Dwelling Unit	1001	$213
HDR	0.15	$143,054	Dwelling Unit	1140	$125
Comm/Ind	0.18	$169,091	Gross Acres	128.37	$1,317
MINERS RAVINE					
SFR	1.01	$1,348,691	Dwelling Unit	2808	$480
HDR	0.05	$69,589	Dwelling Unit	390	$178
Comm/Ind	0.07	$95,272	Gross Acres	50.88	$1,873
SECRET RAVINE					
SFR	1.68	$1,754,183	Dwelling Unit	6046	$290
HDR	0.30	$313,357	Dwelling Unit	2242	$140
Comm/Ind	0.68	$710,516	Gross Acres	484.25	$1,467
ANTELOPE CREEK					
SFR	0.66	$647,791	Dwelling Unit	2468	$263
HDR	0.04	$35,388	Dwelling Unit	267	$132
Comm/Ind	0.13	$129,232	Gross Acres	92.93	$1,391
TOTALS	9.19	$9,027,711			

TABLE 7-7

BILLING RATES FOR ALL LANDOWNERS
(Covers debt service on first costs allocated to all landowners plus all ongoing costs)

User Group	Impervious Area In User Group (Sq. Mi.)	Revenue Need Allocated to User Group	Billing Unit	No. Billing Units In User Group	Annual Bill Per Unit
MAIN STEM					
SFR	3.04	$916,415	Dwelling Unit	14639	$63
HDR	1.49	$451,081	Dwelling Unit	11161	$40
Comm/Ind	2.73	$824,199	Gross Acres	1,942.18	$424
LINDA CREEK SOUTH					
SFR	0.39	$130,366	Dwelling Unit	1364	$96
HDR	0.01	$3,858	Dwelling Unit	85	$45
Comm/Ind	0.04	$14,373	Gross Acres	30.28	$475
LINDA CREEK NORTH					
SFR	0.15	$49,069	Dwelling Unit	378	$130
HDR	0.00	$0	Dwelling Unit	0	$0
Comm/Ind	0.00	$0	Gross Acres	0.00	$0
STRAP RAVINE					
SFR	0.31	$97,578	Dwelling Unit	1345	$73
HDR	0.03	$10,531	Dwelling Unit	251	$42
Comm/Ind	0.20	$61,991	Gross Acres	140.87	$440
MINERS RAVINE					
SFR	1.24	$545,951	Dwelling Unit	3381	$161
HDR	0.00	$0	Dwelling Unit	0	$0
Comm/Ind	0.00	$0	Gross Acres	0.00	$0
SECRET RAVINE					
SFR	0.88	$330,855	Dwelling Unit	3180	$104
HDR	0.33	$125,891	Dwelling Unit	2495	$50
Comm/Ind	0.76	$286,771	Gross Acres	541.27	$530
ANTELOPE CREEK					
SFR	0.77	$257,018	Dwelling Unit	3120	$82
HDR	0.31	$104,480	Dwelling Unit	2324	$45
Comm/Ind	0.53	$179,030	Gross Acres	379.31	$472
TOTALS	13.21	$4,389,456			

peak flows. In any case, the Flood Control District will need to pay for the improvements. To offset these costs, an in-lieu of detention fee is suggested. The in-lieu of detention fee would be based on the following rates:

Land Use	Suggested In-Lieu of Detention Fee per Developed Acre
Commercial/Industrial	$2,091
High Density Residential	$1,843
Medium Density Residential	$1,346
Low Density Residential	$1,304
Rural Low Density Residential	$1,243
Rural Residential/Rural Estates	$1,097

The above in-lieu of detention fee values cover construction costs only. A significant portion of the cost of a detention watershed is the cost of property acquisition. The following tabulation provides an estimate of the approximate amount of land required to construct a typical local detention watershed.

Land Use	Land Needed in Acres for Local Detention per Developed Acre
Commercial/Industrial	0.10
High Density Residential	0.09
Medium Density Residential	0.07
Low Density Residential	0.06
Rural Low Density Residential	0.06
Rural Residential/Rural Estates	0.05

At the discretion of the Flood Control District, a developer could be required to either build local detention or to pay the in-lieu of detention fee and provide the amount of land needed for local detention.